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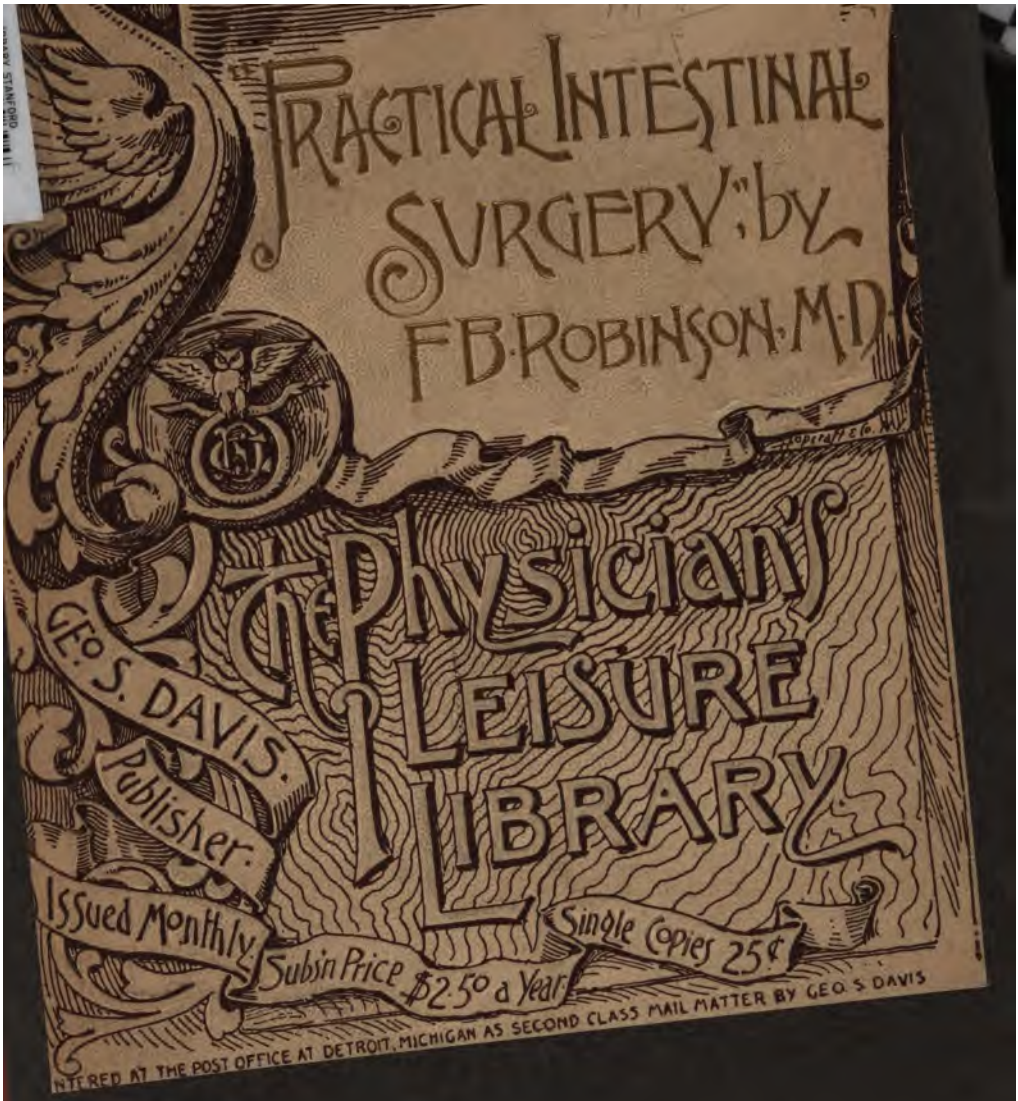
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# PRACTICAL

# INTESTINAL SURGERY

BY

FRED. B. ROBINSON, B. S., M. D.,

*Professor of Anatomy and Clinical Surgery, Toledo Medical College, Toledo, Ohio.*

VOL. II.

"*A word fitly spoken is like apples of gold in pictures of silver.*"—Solomon.

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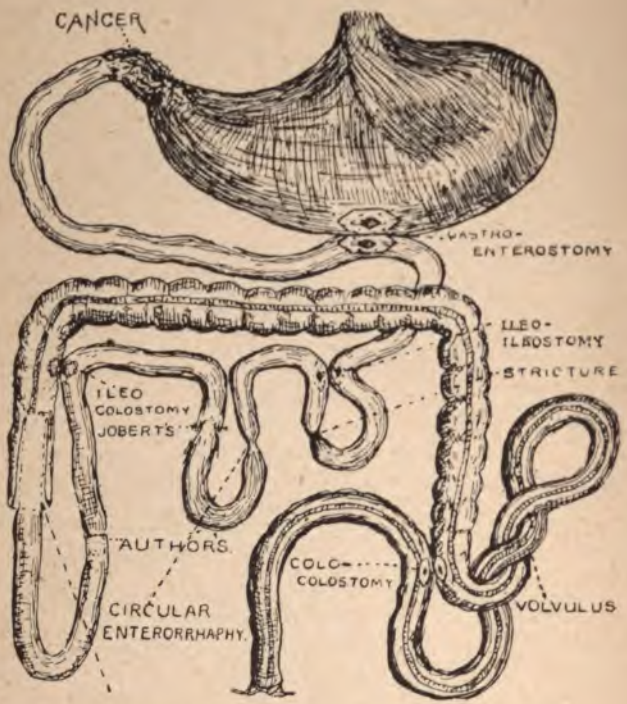


FRONTISPIECE.—Diagram illustrating different intestinal operations.

# VOLUME II.

## CHAPTER XIV.

### GASTRO-ENTEROSTOMY.

Gastro-enterostomy is a term introduced into medicine to imply a communication between the stomach and intestine. It is an operation for the formation of an artificial or bi-mucous fistula between the stomach and some point in the small intestine. The same operation may be extended to some part of the colon. It was first performed by Wölfler of Vienna, in 1881, who began an operation for pylorectomy, and being unable to execute it from local conditions, ended the scene with a gastro-enterostomy. Since that time Billroth, Lauenstein, Senn, Rydygier, Barker, Rockowitz, Stamm, Ranshoff, Page, Monastryski, Czerny, Hahn, Winslow, Postowski, and others, have practiced and advocated the operation. The records of some 105 operations for gastro-enterostomy are extant, but I surmise some of these are repeated reports of the same cases. The object of the operation is to overcome obstruction of the pylorus by directing the fæcal circulation through another channel. Gastro-enterostomy is a rival and a substitute for pylorectomy, and is fast displacing the latter operation. The most favorable report comes from Prof.

Luecke of Strasburg, who did eight operations, with seven recoveries. It was an unsafe operation under the old method of time-consuming suturing, but modern aggressive surgery, with its plates and rings, can do the whole operation in thirty minutes, making it a safe and reliable procedure. When we consider that 35 per cent. of all cancers attack the stomach, and of all stomachic cancers, 60 per cent. attack the pylorus, then the operation rises to supreme importance. It appears reasonable that gastro-enterostomy should be substituted for pylorectomy in cancer of the pylorus, for autopsies demonstrate that one-quarter of pyloric cancers exhibit carcinomatous deposits in the liver. In such cases the dangerous pylorectomy is almost useless, while the safer and more easily performed gastro-enterostomy will relieve indescribable suffering to the end of life. Even for non-malignant neoplasms, stenosis, and occlusions of pylorus, gastro-enterostomy has all the advantages of pylorectomy in physiological processes, besides less shock and violence to the system, as well as a supremely significant short operation. Time, and plates and rings, are the elements of success in intestinal anastomosis. I consider the plates and rings just as applicable to man as to other animals. The rock and base of gastro-enterostomy has already been successfully laid in animal experimentation.

*Experiment No. 4.*—Bitch; weight, 12 lbs. The abdomen was shaved and well cleaned, an

incision made in the linea alba, a piece of small intestine drawn out of the wound, incised an inch on its convex side, and perforated. A sole-leather plate, an inch wide and 2½ inches long, was inserted in the bowel. The plate was armed on each side with a double linen thread, each containing a needle, and each end of the plate was armed with a double thread having no needle. The needles were now passed from inside the gut outward on each side, about a third of an inch from the incised margin of the intestine. The index and middle finger were introduced, and the stomach drawn out of the wound and incised an inch and a half. A similar but larger plate was inserted into the stomach, and its lateral needles pushed through the stomach walls about one-half inch from the margins of the wound. The serous surfaces corresponding to the size and position of the plates were well scarified. The plates were now placed *vis-a-vis* and tied together. Just before the tying of the plates, the margins of the wounds of the stomach and intestines were carefully stitched together, as well as the scarified surface, with continuous suture. Three interrupted over-sutures were added to still further coapt the serous surfaces on the margins of the plates. A graft of unsevered omentum, 2 by 3 inches, was applied over the bowel and stomach, anastomosed, and held in position by four fine linen sutures. The whole being now returned to the abdominal cavity,

the incision was closed by a double linen thread. The needle was passed through skin, muscle and peritoneum, three stitches to inch. The dog recovered with no bad symptoms; he ate nicely, was playful and active.

Seventeen days after the operation, the dog was chloroformed to death. Autopsy revealed the peritoneal cavity perfectly healthy. Plates just as when put in, except softened and slightly absorbed. The peritoneal graft was solidly and firmly grown down to operated parts. It enclosed the wound as a sheath, vastly strengthened its walls, and acted as a barrier against fæcal fistulæ. Its adhesions were so strong it would tear before it would separate from the intestine and stomach. The anastomosis was alone five feet from the duodenum. Some food went through the pylorus, but nearly all went through the artificial opening. The five feet of gut from pylorus to plates was almost entirely empty, contracted, and did not appear vascular. The dog showed no marasmus, but enjoyed excellent health every day, though a bundle of straw had lodged on the proximal side of the plates. The whole abdominal cavity was clear and healthy, showing no trace of inflammation. The wounds of the stomach and intestine had contracted so as to freely admit the thumb. It felt just like a sphincter existing between stomach and intestine. There was considerable thickening around the margins of the apperture from cicatricial

tissue. The dog was fed on water and cooked corn-meal. Water turned into stomach went almost entirely through the newly formed opening.

Remarks: Would the plates finally absorb; if not what would become of them ? The plate of sole-leather in the stomach would gradually absorb, but the plate in the intestine would likely not absorb, but pass per rectum. Practical experience showed that the plates tended to move towards the stomach, and also that, as the threads broke or ulcerated through the tissues, the stomach plate gradually absorbed in the digestive fluids, while the intestinal plate was passed per rectum. If such a dog is fed on soft soluble food, the plates will make no obstruction, for months at least; but if allowed to roam about the city, accumulations of debris, straw, bones, etc., will collect on the proximal side of the plates and form a dangerous obstruction. The straw and hay will entwine itself around and among the plates and dilate the artificial orifice sometimes to double its original size. Such plates may remain in position for many weeks without showing a sign of ulceration of the mucous membrane. Practical experience teaches that the artificial openings made between stomach and intestine will, when healed, be found to have contracted from one-third to one-half the original size and, therefore, one should use large plates and cut quite large openings.

The plate for a dog weighing 40 lbs. should

be (for the stomach), three inches long and one and one-half inches wide, and the incision should be one and one-half inches long. The small intestine plate for same dog should be, one inch wide and two and one-half long. The needles used should be the ordinary round milliner needle. From a long experience with silk and linen thread, I find that the ordinary linen spool thread answers just as well as silk for intestinal suturing and closing the abdominal walls. The excellent health, normal appetite, and playful spirit of this dog, from the day of the operation until the day of execution, shows that gastro-enterostomy is not a formidable or even dangerous operation. A large bundle of straw was found insinuated around the plates, but it did not obstruct food passing.

*Experiment No. 16.* — Dog; weight, 10 lbs. The animal was chloroformed, his belly shaved and well washed. The median incision, beginning just below xiphoid cartilage, was three inches long. The small intestine was seized between index and middle fingers, and drawn out of wound, and laid in a hot cloth. The convex side of bowel was incised one inch long, and a perforated sole-leather plate, armed with four double linen threads, introduced into the gut. The needles, placed on the lateral sutures only, were pushed through the entire gut-wall, one-third of an inch from margin of wound. This was laid in warm cloth, and the index and middle fingers inserted in abdomen brought the stomach out of the wound.

The serous surface of wound to be coapted, was well scarified, and the one lower needle-armed suture tied. The margins and surfaces, of stomach and intestinal wounds were then stitched together by continuous suture, from below upward, and the whole united with continuous suture; the end sutures, having no needles, were tied, then the lower, finally, the second, or upper, needle-armed suture tied.

An unsevered omental graft, two by four inches, was stitched over the wound, with the same continuous suture which was used to unite the margins and serous surfaces of the wound. The whole wound, given fixation by the approximated plates, was returned to the abdomen, which was closed by a double linen thread. The needle was passed through skin, muscle, and peritoneum, three times to inch. The stomach was difficult to draw out of the wound, and by pulling quite hard, the dog's respiration and heart-beat so lessened I thought him dead. Hanging up by the heels, with artificial respiration, resuscitated him in six minutes. To experiment on this dog, I tried pulling on the stomach again, and he again appeared dead, but similar action to aid heart and respiration, again resuscitated him. The sympathetic and splanchnic nerves are closely connected with the medulla, abdominal organs, and heart, hence violence to any of these viscera, causes shock to respiration and circulation through the medulla, which contains the automatic centers of these vital functions.

The quickest way to relieve shock of the abdominal viscera is, to pour hot water into the peritoneal cavity. This revives peritoneal circulation, the sudden slowing of which probably caused the shock. I have produced these shocks several times in extirpation of the spleen, by dragging on it while ligating the gastro-splenic ligament. I think several animals died from such shock.

At the end of seven days, the dog bit the stitches out, so that the superficial part of the abdominal wound gaped. This was re-sutured. He was active and playful, and ate well for eight days, but lost some flesh. After that he began to gain flesh, and was healthy at the end of eighteen days, when he was killed with chloroform. The whole abdominal viscera was perfectly healthy. Both the plates were found in the stomach. The anastomosis was perfectly established and nicely healed. The jejunum looked like a circular tube passing through a section of the stomach; it dipped in and out of the stomach, as the pubic artery dips in and out of the pelvis over the spine of the ischium. The plates were not soluble enough, and therefore are unsuitable material for intestinal anastomosis. The plate was inserted into the jejunum some three feet below the pyloric orifice. A stream of water, turned from the hydrant into the stomach, went almost entirely through the artificial fistula; the fistula easily admitted the thumb. Scarcely any passed through the pylorus. The excluded three feet

of gut was contracted, empty, and not so vascular as that exercising its physiological functions; no food was found in it. The mucous membrane was pale, so that the evolution of the excluded intestine by decreasing action is, to become obsolete. The omental graft was perfect; it was grown over the parts fast and firm. Considerable cicatricial tissue had proliferated between the serous surface of the wound and the unsevered omental graft. The dog had eaten a meal 2½ hours before his death, and scarcely a morsel had left the stomach. There were quite a number of adhesions in the abdominal cavity. The ascending colon, two inches above the cœcum, had grown fast by an adhesion to the stomach. In these operations, an attempt should be made to have the resulting bimucous or artificial fistula present an orifice of the same size as the original, natural openings.

Remarks: The points to be learned here are that sole-leather will not absorb quick enough, that the artificial fistula contracts from ½ to ⅔ its original size, that it is safest, when possible, to completely sever the omental graft, that no raw places should be left uncovered in the abdominal cavity, and that the most remote organs will form adhesions and act as bands to strangulate the intestines in future years. It shows that a long piece of gut can be excluded and left in the bowels, that the fæces will be driven out by peristaltic and anti-peristaltic action, will take the direction of least resistance, and that

use alone will keep a bi-mucous fistula open. Both this and the preceding dog shows that the operation of gastro-enterostomy does not affect the system very much by shock, but affects it profoundly through nourishment. Both dogs show that the evolution of a sphincter is a gradual growth from use. The periodic dilatation and contraction of this artificial fistula between stomach and bowel, gives it a distinctly sphincter-like appearance, action and feel. Here also can be observed the fact that almost three weeks passed with hard sole-leather pressing continually against the mucous membrane of the stomach and bowels, with not the least sign of injury. No ulceration or even traces of inflammation could be detected. The dogs were allowed to eat and drink at liberty. The food consisted of cooked corn-meal and soft foods from the table.

The animals recovered promptly from the operation of gastro-enterostomy though subject to very unfavorable conditions, as a barn or cellar, with no dressings for the wound. The animals kept the wound clean by licking it. I think that the same operation on man will be accompanied with equally good or even better resuts from the very environments. With man a technique of physiological rest and cleanliness can be executed. It will be the operation for pyloric or duodenal stenosis in man in the future.

Gastro-enterostomy will be the boon that will

relieve the terrible suffering of cancer in the pylorus. It will relieve vomiting, permit physiological rest to pylorus, retard malignant growths by slowing functions, and thus allow the patient to pass his remaining days relatively free from agony, and brightened by the hope of recovery.

*Experiment No. 18.*—Dog; weight, 20 lbs. The material for anastomosis was raw-hide plates of belt leather. The plates were cut diamond shaped, 2½ inches long and 1 inch wide. A diamond shaped perforation, ¾ by ½ inch, was cut in the center. The plates were also perforated by four holes with an awl for the two double linen threads, armed with a needle each. The needle was passed through the end awl hole and returned through the lateral awl hole. The double thread was two feet long. The belly was shaved, and a four inch median incision made. The small intestine was drawn out, and a hole cut one inch long on its convex side, through which the raw-hide plate was introduced. The needles arming the lateral structures, were pushed through whole thickness of the gut from inside, outwards one-half inch from margin of wound. The index and middle fingers drew the stomach out of the incision, and in the most dependent part of the stomach, with the avoidance of the gastro-epiploica sinistra (vein and artery), an incision one and one-half inches long was made. A similar plate was inserted in the stomach. The lateral needles penetrated the whole thickness

of its wall. The margins of wounds of stomach and intestines, were sutured by continuous stitch. The lower needle-armed suture was now tied. The stomach and intestinal serous surface corresponding to plates, was well scarified and stitched together by continuous suture. The three remaining plate sutures were then tied. A few over sutures were applied to add strength to the coäptation. An omental graft, scarified, was applied over the whole surface, and sewed down with six fine linen stitches. Abdominal wound closed by a double linen thread, including three sutures to inch, and the skin, muscles, and peritoneum. The operation caused no shock, and the dog awoke and walked off apparently happy.

Dog killed 18 days after operation; he had done well; played; ate voraciously; had lost some flesh, about three pounds The median incision had healed perfectly. The abdominal organs were normal. The plates were entirely gone. Two of the threads were left looped in the wound, which of course, were the sutures armed with needles. The anastomosis was done about four feet from pylorus in jejunum. The new opening or artificial fistula looked just like a sphincter. It easily admitted the index finger, and had contracted about one-half from original size. Water turned into the stomach from faucet showed that fluid passed equally through both pylorus and artificial fistula. The omental graft was a sure and distinct protection for the anastomosis; it

hermetically sealed the whole like wax melted over the mouth of a bottle. No spur or kink was demonstrable at the point of anastomosis.

In approaching the stomach, instead of shoving the whole great omentum to the left, a hole was broken through. Through this opening, 3×4 inches, some 6 feet of small intestine and its mesentery had insinuated itself. It looked very suggestive to see that roll of viscera hanging outside the great omentum through a hole in it. No doubt that aperture would be the seat of future strangulations and adhesions.

Remarks.—I have not known of raw-hide plate being used in anastomosis, but have demonstrated by many experiments that it is perfectly feasible. I have never known of raw-hide plates failing to absorb in the stomach or upper portion of the prima via. If too much tannin, alum, or other material, is not employed in the preparation of the leather, it will always absorb. Green hide with the hair shaved off, and kept in alcohol, is one of the safest materials for intestinal anastomosis. Drying it stiffens and thickens the plates so that they can give fixation to the anastomosed part. The raw-hide, which I experimented with in the above case, is ordinary belt leather. I would suggest that all plates be sutured with two threads at least, and a needle be placed on the four ends. It saves much time, and I think is more secure, to discard Prof. Senn's original method

of applying the threads to the plate. It consists in simply passing the thread through the end awl-hole, and returning it through the lateral awl-hole. I am now in favor of 6 needles armed with 6 sutures for each as in the rubber plate. In listening to Prof. Billroth's lectures on his experience with the human stomach relative to where the duodenum should be inserted into the stomach, he suggested it should always be applied to the lowest and most pendant portion of the latter. He said he had tried the idea of inserting the duodenum quite high in the stomach, and the result was the patient suffered considerably in getting the food out of the stomach into the intestines. Many dog experiments have demonstrated to me that the artificial fistula should be put in the lowest part of the stomach, so that the food can pass out, and so that the natural secretions will aid in keeping open the artificial fistula, as one can expect it to contract from one-third to one-half its original size. In the above case, some four feet of jejunum and duodenum were excluded, partially from physiological action. This occurred from mistake, and was not so intended. The more gut excluded, the more dangerous to the animal. To avoid this danger, one must learn by experience to secure the part of gut he wishes to anastomose. The suggestions of Prof. Luecke and others, must be discarded relative to seizing the first distended loop of intestines and using it. That might be allowed under the

time-consuming operations of old, but is not suitable to-day. I consider it justifiable to condemn it, though from so eminent authority. I have several times made this same mistake, and the result is generally marasmus for the unfortunate animal. Once I thought I was uniting the upper end of the jejunum to the stomach, and the autopsy proved it to be the lower end of the ilium. At another time I supposed I was uniting the transverse colon, and post-mortem showed it to be the rectum. Practical experience, from operations and autopsies, has convinced me that the best method to do gastro-enterostomy and avoid marasmus, is to pass the index and middle fingers into the abdominal cavity, and shove the great omentum, entirely to the left; then feel for the stomach, pylorus, duodenum, and pancreas, and by the lumpy, boggy feeling of the head of the pancreas, and the fixation of the duodenum, one can find the upper end of the jejunum. Another observation may be made here, and that is, that over seventy closures of abdominal incisions by including skin, muscles, and peritoneum, has resulted in no hernia; that the cicatrix is one-third, one-half, and twice, as thick as the original abdominal wall. I have seen it result in at least three times the original thickness. A little more than 3 stitches were placed to the inch.

*Experiment No. 21.*—Dog; weight, 35 lbs. This animal was old, and his peritoneum loaded with large rolls and pads of fat; employed usual rawhide

plates of belt leather. The usual preparations, and median incision, were made in a hot room; the jejunum and stomach incised and plates inserted. The usual marginal and serous surface suturing, over-suturing, and scarifying was done, omental graft applied, and abdominal wound closed by including skin, muscle, and peritoneum in each stitch, three stitches to inch. The operation required some thirty minutes, and dog rallied well.

Dog died 50 hours after operation. The cause of death was intestino-peritoneal septicæmia from a fæcal fistula. The fistula occurred from inserting the needle too deeply at one point in making a serous suture. The plate in the stomach was one-third absorbed; the third absorbed was nearest to the pylorus. The plate in the intestine was fairly well softened, but not absorbed. The omental graft had formed very strong adhesions.

Remarks.—This death occurred from an error in operating. One must learn by experience, and much practice, how deep to insert the needle; much of this is learned by feeling. The fistula might also have arisen from a stitch tearing through by dragging of the parts. This autopsy showed that rawhide plates will absorb. One of the great advantages of the plate in anastomosis is, that it shortens the time of operating. The old suturing required an hour; the same skill will anastomose with plates in twenty minutes.

*Experiment No. 24.*—Dog; weight, 20 lbs. He was very old, as was shown by rolls and pads of fat in peritoneum. Material for anastomosis was the usual rawhide plates of belt leather. Animal chloroformed; belly shaved; median incision. The large intestine, supposed to be transverse colon, was drawn out of wound, incised on its convex border, and the rawhide plate pushed into the one-inch incision. The plate was 2½ inches long and 1 inch wide; the central perforation was ¾ inch long and ½ inch wide. The index and middle fingers drew the stomach out, and at its lowest point, midway between its cardiac and pyloric portion, an incision 1½ inches long was made. The margins of wounds and serous surface were stitched together with continuous linen suture. The plates were approximated and the corresponding threads tied; two over-stitches applied and dropped into abdominal cavity. No peritoneal graft applied. Abdominal incision closed by three sutures to inch, including skin, muscle, and peritoneum. The dog made an uninterrupted recovery, with no bad symptoms. He ate and drank, and appeared to live happily for eleven days, when he was killed.

All abdominal organs healthy; no trace of inflammation could be seen; plates entirely absorbed. Only one piece of linen stitch remained to tell the story of the sutures. The remarkable part of the autopsy was, that the transverse colon was not dis-

turbed, but the rectum, six inches from anus, was attached to stomach. The dog had just enough stomach and gut to reach, in a straight line, from mouth to anus. This connection dragged on the stomach, and this, or some other cause, made the stomach about one-fifth longer than it should be. The stomach dilated in the direction of rectum. Water turned into stomach from hydrant, went through the artificial fistula. Very little could be seen going through pylorus. But the dog did not have marasmus. The artificial opening felt just like a sphincter, and easily admitted the index finger. It had contracted one-half from original size. This small opening would compel the stomach to retain the food a long time, and, therefore, it would absorb most of the elements digestible by stomachic fluids. The result was good without graft.

Remarks.—The mistake of seizing the rectum for the transverse colon, should be remembered. However, the knowledge which enables a man to tell the difference, will only come through experience. I saw a skilled surgeon, with his hand in the belly of a living patient, and he acknowledged that he could not tell the difference between a distended and collapsed small intestine. Prof. Madelung, of Rostock, who has done good work in this department, would often test the pathologists. When a patient died of intestinal obstruction, he would ask the pathologist to introduce his hand in the median incision of the cadaver, and

then give him twenty minutes to make a diagnosis, but the pathologist failed each time; he could not locate the obstruction, even on a dead body, when no fear of violence prevented active manipulation. Only diligent, long-continued, faithful work of experimentation, on the lower animals, and on the cadaver, will ever qualify a man for abdominal surgery, and especially that of the intestines. This experiment shows that the raw-hide plates are absorbable, and proper substances for use in the human.

*Experiment No. 26.*—Bitch; weight, 30 lbs. This animal had the spleen extirpated seventy-eight days, and the cœcum extirpated thirty-five days, previous to the present operation. Material for anastomosis the usual raw hide plates of belt leather. The shaved belly and median incision allowed the small intestine to be drawn out and plate inserted as before. The index and middle finger now searched after the stomach, which it was almost impossible to draw out of the wound, for the old splenic adhesions were very strong. The plates were introduced as before and approximated by tying the corresponding sutures. Abdominal wound closed by three stitches to inch, including skin, muscle and peritoneum. The creature lost flesh for about ten days after the spleen had been extirpated, after that gained flesh until the cœcum was amputated thirty-five days before the gastro-enterostomy performed. From the time of the cœcal

extirpation she slowly but steadily lost flesh, but after the last operation quickly lost flesh for fifteen days when she died a typical skeleton. She ate until the day of death, and ate fairly well, nevertheless died from causes which had no immediate connection with the operation.

Autopsy: The dog died of marasmus fifteen days after the last operation. All wounds had healed well. Abdominal organs were perfectly healthy. Plates entirely gone. The artificial fistula was constricted to half its original size, admitting, in its sphincter-like aperture, the little finger. The threads hung in the wound. The stomach was attached to jejunum two feet from pylorus. Scarcely a vestige of fat could be found in the dog in any place. The peritoneal graft applied to stomach had sealed it all in with a wall of exudate, and held the wound solidly and firmly in its place. No unhealed wound existed anywhere. The spleen had been gone seventy-nine days and in its place were found some adhesions holding the stomach fast to the wall of the chest. The remains of the spleen felt like an old scar the size of a walnut. All the old blood clots had been absorbed.

The cœcum had been extirpated fifty days, and lay just as it had been left. I had invaginated it, after amputating, and stitched in position by some linen sutures, which were absorbed.

Remarks.—The two feet of gut excluded certainly did not cause the profound marasmus which

followed the last operation. The marasmus began slightly with the extirpation of the spleen. It was very marked after the cœcal amputation, and, after the last operation so profound as to cause the animal's death in 15 days. The operations acted on the dog in geometrical ratio. The peritoneum was opened three times in 79 days, and although every wound had become a well-healed scar, mal-assimilation dragged her swiftly onward and downward.

*Experiment No. 37.*—Dog; weight, 25 lbs. This was animal No. 27, on which I had, 10 days previously, performed ileo-ileostomy with segmented rubber rings, of six segments, held together by four strands of green rawhide, with hair shaved off. He had lost several pounds of flesh. Abdominal incision was in median line, anterior to old one, the middle and index finger introduced, omentum shoved to left, and the small intestine was drawn out of the wound. The bowel was cut on its convex surface for one inch and the rubber segmented rings introduced, armed with six sutures. The needles on the thread were pushed from the inside outward, at six points, equal distances from each other, there being one at each end and two on each side of the gut incision. The stomach was then drawn out and incised inches, and treated with a similar segmented rubber 1½ ring. The two wounds next were approximated, and the edges of the stomach and intestinal cuts stitched edge to edge all round with continuous suture, as was

also the scarified serous surface covering the rings. The sutures of the rings were gradually tied from below upwards. All sutures were made of linen thread (Barbour's, No. 60). The parts were well scarified, as well as the omental graft, 2 by 4 inches, which was well applied with four linen sutures of single thread. Operation required 30 minutes.

The animal was killed 8 days after last operation, and 18 days after first. Every organ was perfectly healthy in abdomen, except a mesenteric gland which was as large as a plum. The gastro-enterostomy of 8 days old was well healed. The dog had marasmus to a degree to cause him to lose a half-pound daily. He ate well and drank naturally. The anastomosis was done 3 feet below the pylorus. The rings had entirely disappeared with the linen threads. The artificial fistula had contracted to two-thirds its original size, which corresponds with general experience. Water turned into the stomach passed one-half through pylorus and one-half through artificial fistula. The omental graft ensheathed the parts solidly and firmly with its new adhesions. The unsevered omental graft was obtained from the rent through the great omentum made in approaching the stomach, 3x4 inches. Through this aperture a piece of small intestine with its mesentery had gradually wiggled itself until eight feet hung anterior to the omentum. It had quite a constricted neck.

Remarks.—With increasing numbers of opera-

tions, my wish increases for material proper for anastomosis. The material must be convenient and accessible in cases of emergency; it must have the quality of being made ready quickly, and; must absorb or break down in the alimentary tract at proper periods of time. The more I operate, the more I employ the raw-hide plates introduced by myself, and the segmented rubber plates which I lately invented. These substances will last at least 5 days in the tract—a period which I think is the least time in which proper union can be expected or trusted. Dr. Senn's decalcified perforated bone plates are excellent, but they require too long to prepare, and will often warp after being made. I predict for the raw-hide plates, and segmented rubber plates, a large share in future intestinal anastomosis, for this operation will no doubt supersede most other operations for the purpose of restoring the continuity of the fæcal circulation.

The above operation shows that if omental grafts are to remain unsevered from the omentum, they should not be taken from the central parts, but from the sides. The unsevered omental graft was derived from a central portion of the omentum, and in that case is liable to leave an aperture. The eight feet of gut and mesentery projecting through the omentum could become strangulated by traction and otherwise; this is the second time it occurred in ten cases of gastro-enterostomy. It is best at all times to sever the graft from the omentum when possible, or if not

possible, from fear of losing a weak patient, shove the omentum to left and derive it from the side. I have observed that if apertures or bands are made by any part of the peritoneum, the autopsies show that some intestines, small or large—the most movable having the longest mesentery—will often insinuate and wiggle themselves through the holes and under the bands. Also, all raw surfaces in abdominal cavity should be covered with several grafts of peritoneum.

The causes of marasmus are not always clear. It appears to depend at times on the amount of bowel excluded, physiologically or otherwise. It also depends on the number of operations done in a definite period on the same victim.

*Experiment No. 30.*—Dog; weight, 20 lbs. Material used, belt leather, or rawhide plates, which were slightly tanned. The usual median incision was made when the stomach was anastomosed by the rawhide plates to the small intestine. Omental graft, unsevered, stitched down with four linen sutures. Operation required forty minutes. The dog did well, ate excellently, and seemed to enjoy life; lost a little flesh.

The dog was killed seven days after the operation. Omentum solidly grown to abdominal incision. All abdominal viscera perfectly healthy. The cicatrix in linea alba was almost three times as thick as the original. The stomach plate entirely absorbed. The intestinal plate about ¼ gone. The two plates

had been kept in alcohol in which considerable tannin existed. The omental leaf had grown solid and fast to intestinal and stomach wall. The dog had an artificial fistula, easily admitting the thumb. So far as could be observed, all substances passed by the artificial fistula, and not by pylorus. The opening was sphincter-like, and had contracted about ⅓ from original size. The anastomosis was done two feet below the pyloris.

Remarks.—The thickened cicatrix in the abdominal incision was here observed, owing to the method used from the beginning in closing the belly wall; thus hernia could not arise. The method which I think best is to apply three stitches to inch of a suture which includes skin, muscle and peritoneum. The adhesions of the omentum to the abdominal wall might develop bands and apertures for future intestinal strangulation.

*Experiment No. 32.*—Dog; weight, 20 lbs. This animal had been operated on nine days before with catgut mats for the purpose of accomplishing ileo-ileostomy.

The linea alba incision allowed the intestine and stomach to be drawn out and a green raw-hide plate (with hair shaved off) inserted in each viscus. Each plate was armed with six sutures, which should be separately fastened. The gut incision was one inch, the stomach, one and one-half inches. The incised margins of the wounds were united with continuous

suture as well as the scarified serous surface. When the operation was finished, one-fourth to one-half inch of scarified serous surfaces coapted.

An omental graft was scarified and applied over the anastomosis and held in position by four fine sutures, which generally were inserted into the mesentery or concave side of bowel.

Operation required thirty minutes. The animal acted lively and seemed to be happy. He ate ravenously, but lost considerable flesh.

The dog was killed seventeen days after first operation and eight days after the last. The abdominal organs were in perfect health. The gastro-enterostomy had healed perfectly and proliferated considerable cicatricial tissue around the new opening; it was firm, solid and sphincter-like, easily admitting the thumb; it had contracted almost one-half from the original size.

The anastomosis was done three feet below pylorus, and the jejunum seemed to run through the stomach like a U tube. The omental graft had firmly and solidly grown all over the wound and had no doubt helped to save the dog. The plates were all gone. No track of plate or stitch of linen was visible. Eight, days sufficed for total expulsion, and I think they had been gone for two days. A careful examination showed that the stomach contents passed almost entirely through the artificial fistula and not *per vias naturalis*. Peritoneal adhesions were not to be found except at points of operation. Abdominal incision had healed by regular method, solid and firm.

Remarks.—These operations seem to me, to demonstrate that rawhide plates and segmented rubber plates, are perfectly proper material for intestinal anastomosis, and can be used with absolute safety on human beings.

From convenience and ease in making, I am now more and more inclined to use the rubber plate, which is the most ideal plate known.

*Experiment No. 153.*—Gastro-enterostomy. Dog; weight, 20 lbs. Animal chloroformed, belly shaved, and median incision made of 4 inches. The pendant portion of the stomach incised 1½ inches and a segmented rubber plate inserted, and six suture-armed needles passed through into walls ¼ inch from the margins of the wound. Eighteen inches below a loop of small bowel was drawn out, and a like plate similarly introduced. The serous surface was scarified, plates approximated, and corresponding sutures tied. Two over and under lateral sutures were used to add strength. The operated parts were well covered with an omental graft held in position by sutures. The second day the dog vomited some, and urinated quite frequently. From the third day he ate, drank, and played, as if he were healthy and happy, until he ran away on the eleventh day, and was not recaptured.

The segmented rubber plate has proved very convenient and useful in intestinal anastomosis. I invented it from necessity, because it is the only ma-

terial that a surgeon has with him always, viz.; catgut for a ring, and an Esmarch for the rubber segments.

*Resumé*—The dogs were turned loose in a cellar six to ten at a time, with different kinds of experiments performed on them. They ate, drank, played, and fought away the time. The fighting often injured them, and killed some, as the intestines would be found hanging out of the reopened abdominal wound. Sole-leather plates were used on two with good results, but abandoned as unsuitable by reason of being too unabsorbable. Belt-leather and rawhide were used on five with perfect success: Segmented rubber rings (Brokaw's) were used on one; green, soft rawhide on one. The segmented rubber of the author was used on one. The pressure of plates (even sole leather) caused no ulcers on the mucous membrane. Marasmus killed one, and affected two others considerably; seven showed no marasmus.

The technique, of operation, was a success in nine, and a failure in one. More work was done in gastro-enterostomy, with about equal results, but not here recorded. The above are sufficient to demonstrate the operation, and its effect on animals. It also shows the technique, the value and effect of the different "aids" in performing the operation. It may also be observed that gastro-enterostomy is not a very formidable or fatal operation; that recovery is to be expected under ordinary circumstances. I would suggest that the proper skill and dexterity required to

perform it on man, should be acquired from experiments on dogs. The results of gastro-enterostomy are on trial in every land. The final physiological and anatomical effects on life must be determined by observation on the subsequent life of the animal operated on. Autopsies must be the landmarks in the operation. The observation must include many cases, through many years of distinctly recorded work, so that many minds can read, criticise, and judge, and thus be able to modify the surgeon's course by opinions—which are stronger than armies. Brilliant single-case results should not dazzle the eyes to generally observed effects by good specialists. Extended clinical research is the only excuse to claim any authority in the matter. The results are of two kinds—one to relieve suffering, to the inevitable end, in malignant diseases; this it does well in general: The other is, ultimate cure of the obstruction; this it does well in general. From Billroth's clinic in Vienna, Czerny's clinic in Heidelberg, Luecke's in Strasburg, and Lauenstein's in Hamburg, have come the most reliable instruction yet known in Europe. Prof. Czerny did eleven operations, with eight recoveries, but the conditions of the patients precluded long subsequent life. Prof. Luecke did eight operations, with seven recoveries, but the subsequent life is not recorded. Prof. Senn, so far, is doing the most work in our own country, with good results.

# CHAPTER XV.

## PATENCY OF THE ILEOCŒCAL VALVE.

### I. CAN FLUID BE INJECTED THROUGH THE ILEO-CŒCAL VALVE FROM THE RECTUM?

At first thought one would think that such a question should be answered by yes or no. This age of investigation has taught men that Nature does not work by the yes-or-no rule. Nature's laws, though always fresh and new, are modified by so many unseen conditions that they can not be hemmed in by mathematics and unqualified assertions. It seems that history records distinct experiments to test the validity of the competency of the ileo-cœcal valve against fluids for some 300 years. Written opinions have varied from then until now over this subject. Different ages and localities, with men of vast and varied acquirements in anatomical and physiological knowledge, make up the positive, conditional and negative opinion classes. The following well-known names record their opinion that the ileo-cœcal valve is not safely permeable to fluids from the rectum: Herschel, Bull, Lucas, Dawson, Senn, Meckel, Cruveillier, Doudars, Hall, Treves, and others.

On the other hand, the following names are not without reputation, who assert that fluid will safely pass the ileo-cœcal valve: Battey, Illowa, Riolan, Hallar, Morgagni, Gantani, Kerckring, and others.

There is a third class of men who say that it is wholly conditional on the valve itself whether the fluids will pass safely or not. In this class may be noted such men as Leichtenstern, Debirre, Hegar, and many others. It seems to the author that the most rational idea is the condition of the valve. I can assert positively that in man experiments demonstrated, in some cases, the fluid would not pass the valve with all the force I could use on a bulb of Davidson's syringe. In others, the fluid passed after considerable continued pressure. Again, it would pass the valve with comparative ease. In some cases the bowel would rupture before it would pass the valve and arrive in the ileum. The lacerations would occur along the side of the bowel in the peritoneal covering. The ruptures generally occurred multiply, and rarely singly. Dogs were tried in three conditions: (*a*) When the dog was awake the injections passed the valve with great difficulty, (*b*) when the dog was under chloroform the fluid passed the valve easier, and (*c*) when the dog was dead the fluid passed the valve the easiest, and in the greatest number of dogs. A goodly number of experiments were made on the valve with the abdominal wall removed, when the mechanical process could be distinctly observed. The fluid would pass the valve with less force when the abdominal wall was removed or relaxed by narcotics.

*Experiment No. 94.*—The ileo-cœcal valve of

man was exposed by removing the abdominal wall. A bulb syringe forced water into the colon. The force was applied until the water was seen to trickle through into the ilium. The cœcum became highly distended when the valve became tense, like a circular curtain filled with wind. Heavy pressure from the syringe would force a few drops between the edges of the valve. If still heavier pressure was used, the water would squirt through in the form of a thin sheet. The moment the force ceased, the margins of the valve effectually closed the aperature.

Careful examination of the colon and its covering afterwards showed that the peritoneum was ruptured with but little water yet in the ilium.

*Experiment 91.*—A male cadaver was used, with the abdominal walls removed. It was found impossible to force water through the ileo-cœcal valve with a bulb rubber syringe. The force was continued until the circumference of the colon was almost fifteen inches, but no water escaped into the ilium through Bauhin's valve. The peritoneal coat was ruptured on the colon.

*Experiment No. 92.*—Dog; just killed from chloroform, and water was injected with all the force compatible with integrity of gut and peritoneal tissue, but no fluid was found beyond the valve.

*Experiment No. 93.*—Dog; chloroformed, and water injected while under the anæsthetic. The fluid passed through the valve quite easily, without damaging any tissue.

*Experiment No. 101.*—Female cadaver. This woman had a very much elongated mesentery and dilitation of bowels. Water was forced with heavy pressure, from a bulb rubber syringe, into the colon. The abdominal walls were removed, and the whole process was visible. The forcible injection was continued until the peritoneum had quite a number of longitudinal lascerations on the lateral sides of the colon. At the climax of this force water would just trickle through the ileo-cœcal valve, between the margins. The valve would distend in circular form, like the segment of a sphere forcing the edges mechanically apart, just as an excessive column of water applied to the aortic valves would mechanically drive them asunder, allowing the fluid to trickle between the edges. On relieving the force, the valve of Bauhlin quickly returns to its original condition. The fluid forced through this individual valve was incompatible with living tissue. It would no doubt have killed the woman.

*Experiment No. 102.*—This will include quite a number of experiments on dogs and the intestines of cattle. The ileo-cæcal valves of dogs were taken out and so dissected that the valve was distinctly visible on the side of the ilium. Water was then injected into the colons of these respective valves. The colon would gradually fill, and then the valve would gradually distend itself like a balloon. It filled like the sail of a ship, and finally, when the mechanical dis-

tension became sufficient, the margins of the valve simply separated, and the water either trickled or went through in a fine stream or sheet. The pressure in nearly all cases was adequate to rupture the peritoneum covering the bowel. It is quite safe to assert that in the majority of cases the ileo-cœcal valve in man, dog, and calf, is impermeable to fluids from the rectum under force compatible with safety to life. The intestines of a large calf were injected, per rectum, with water. The cœcum distended to a dangerous degree, but no water passed Bauhin's valve. Such distension would be incompatible with life; hence the conclusion from the experiment is, that it is unjustifiable to attempt to force fluids from the rectum through the ileo-cœcal valve in man. Of course, one must not confound dead animals with living ones, but the experiments on dogs showed that reflex irritation caused more obstruction in the valve when the dog was awake and well than it did when he was narcotized, and still less force was required to send water through the dead dog's valve; even dead dog's intestines showed multiple lacerations as well as the dead human.

Relative to fluids being forced through Bauhin's valve from the rectum, I would call attention to the following conditions:

1. The permeability of the valve to fluids depends much on its anatomical structure. If both the lips are long, it offers much resistance; in the major-

ity of such cases, sufficient resistance is caused to rupture the peritoneal coat of the bowel. Occasionally one lip is shorter than the other, and this favors permeability, especially if it be the lower.

2. Experiments demonstrated that the highest resistance to permeability occurred in the valve of a healthy, awake animal; the next highest resistance occurred in an anæsthetized animal; and the least resistance to permeability occurred in dead animals. But lacerations occurred in the dead human and dog, even under the least resistance.

3. The safest method of introducing the fluid is by a fountain syringe, under slow but long-continued pressure; probably the knee-and-elbow position aids.

# CHAPTER XIV.

## INTESTINAL OBSTRUCTION.

Intestinal obstruction should constitute the most important chapter in the surgery of this field. The cause which produces one death in 350 is amply significant to demand attention. Intestinal obstruction, occlusion and strangulation will be considered as synonymous terms, as each is sufficient to impede fæcal circulation and be accompanied by the demon, gangrene and its relative inflammation. The cause of the obstruction must lie outside the bowel, in its wall or in its lumen. The causes which produce obstruction external to the intestine are the pressure from tumors, enlarged viscera, exudates, natural or artificial peritoneal bands, apertures in the peritoneum and contractions of peritoneum. Obstruction produced by the walls of the intestines are very frequent and arise from both a healthy and diseased wall. Occlusion from a diseased wall may be cancerous, inflammatory, cicatricial, or from paralysis; also from a healthy wall obstruction arising from, volvulus, kinking, flexion, knotting and invagination. Those causes of obstruction having their origin in the intestinal canal, are hardened fæces, intestinal and biliary calculi, enteroliths, foreign bodies, neoplasms.

Most of these conditions are spoken of in different parts of the book. Here, however I will treat

only of complete acute obstruction. In the experiments I produced many kinds of twistings and acute flexions, but in hardly a single case did complete obstruction arise. I produced complete, acute obstruction by tying a strip of gauze around the dog's intestine with sufficient firmness to impede fæcal circulation but not to impair vascular. Gangrene is the one almost constant appearance found at the autopsies; this arose from the return venous blood being prevented. The gangrene occurred at the points where there was the least resistance to the collections of fluids, and this was at the middle of the convex border of the bowel. At the convex surface of the gut the œdema first arose, and hence here is where the venous blood meets with the obstacle which cuts off its return. Violent peristaltic action rapidly increases the condition which induces gangrene. Gangrene first began in a little spot and spread as the venous blood collected with inability to return. It was not arterial insufficiency that caused the gangrene, as in that case a whole loop would be gangrened at once, as occurred in gunshot wounds when the entire arterial supply was shot off. In such cases I have seen nearly two inches gangrene to blackness in 40 hours. In these cases vomiting and violent peristaltic action increases in severity with time. Opiates, of course, give wonderful relief and prevent such rapid destruction, but it should be used with caution as it obscures the symptoms and blinds the surgeon's eyes to early

operation which might avoid indefinite complications, and even death.

Here, I will allude to a number of experiments which interested me very much They embrace a field as yet not explored, and scarcely entered. The idea which I gained from the experiments, is that reflex irritation at the seat of obstruction, is the main disaster that wrecks the subject into suffering. Reflex irritation at the seat of strangulation is the fury that quickly induces one disturbance to follow another, carrying the patient swiftly onward and downward. Reflex irritation invites peristalsis with all its sequences of destructive changes at the seat of occlusion. To prove this two kinds of experiments were carried out. One was by tying a strip of gauze around a gut and droping it back into the belly; this was always followed by dire sequences of reflex irritation, vomiting, wretching, violent peristalsis, and almost constant pain for some time. Though the subject seemed to be in constant pain, yet waves of exacerbation would come and go at irregular intervals. The animal appeared as the very picture of distress. The whole alimentary canal was violently disturbed by peristalsis, as was shown by the vomited, secreted, fluids; especially could this be seen by watching the saliva run from the dog's mouth, showing all the glands in active secretion. The lessening of the animal's vitality could be observed by the flaccid, limpid condition of the muscles.

Another set of experiments was performed by opening the dog's belly and drawing out a loop of intestine and completely severing it, invaginating both ends, and fixing them in position by a few Lembert, continuous sutures, then closing the abdomen. I have now a dog with complete obstruction. The ilium is completely divided, with its ends closed by invagination, causing no irritation at the seat of occlusion. No nerves are injured or compressed at the point of obstruction. Reflex irritation is almost absent, the dogs play and jump, and they appear almost free from pain; they eat a little and are apparently happy. The difference between irritation at the seat of strangulation and none is absolutely wonderful in clinical and pathological manifestations. It is mainly accounted for by reflex irritation. I think that a dog under the condition of no irritation at the seat of occlusion would live months. He would eat and absorb the food, and probably vomit once in a while to relieve the over-distension. I hope in future to investigate this field of experimentation. In intestinal obstruction the essential disturbance arise from the accumulation of fæces on the proximal side of the occlusion. This is what causes so much disaster in vomiting, pain, and violent peristalsis above the seat of structure. Dr. Kussmaul, of Strasburg, introduced a long rubber tube into the stomach for the relief of this disturbance. Fluids are then poured into this viscus by means of the tube, which can then be used as a siphon, by low-

ering it, and thus draining out the contents of the stomach and of the upper part of the intestinal canal, especially those which could regurgitate through the pylorus. Various physicians claim the following points for this remedy: 1. It prevents distressing symptoms: 2. It lowers intra-abdominal pressure: 3. It relieves distention by evacuation: 4. It lessens peristalsis: 5. It cures the disease. By removing the contents of the intestines above the seat of obstruction distention is kept down. One often sees remarkable relief from the administration of a stomach irrigation, and an important point is gained by the fact that large amounts of food dissolving in considerable fluid secretions quickly decompose and become the home of luxuriant growths of pathogenic microbes, that can be largely washed out with the pabulum on which these vegetable germs subsist.—Few men who investigate the subject will deny the rôle played in peritonitis by these germs. The alleviation from washing out the stomach should not be allowed to obscure the symptoms so as to improperly delay an operation.

The following experiments will explain and speak for themselves.

*Experiment No. 52.*—Dog; male; weight twenty pounds. Animal chloroformed, and loop of ilium drawn out of median abdominal incision, and tied with a strip of gauze soaked in alcohol; the gauze was tied firm enough to completely obstruct fæcal

circulation, but loose enough to permit free blood circulation; abdomen closed. Two days after, abdomen re-opened. The obstruction was found encapsulated with lymph and recent adhesions. The gauze had caught part of the tail of the pancreas in it when it was tied and amputated it. I anastomosed the bowel above, to the bowel below the obstruction, with raw-hide on one side, and ordinary top-boot leather on the other. Each plate was armed with four sutures, and four needles. The serous surface was scarified, the plates approximated, and tied by the corresponding sutures on each plate. An omental graft was applied, and sutured in position. The gauze causing obstruction was clipped, and drawn away, and abdomen closed. The proximal gut was dark and patulous. Some œdema, filled with gas and considerable liquid fæces. The distal gut was collapsed and natural in color.

The dog died on the third day from infective peritonitis. The autopsy showed the anastomosis to be healing perfectly. The dog had withstood the first operation and resisted infection, but the surroundings of improper appliances insure infection which ended the scene. If I could have been perfectly clean, the dog would have lived, for it was infection that killed and not the operation. The dogs with complete obstruction by gauze, were ready to vomit and gag at any moment by arousing them to activity. But in partial obstruction, vomiting and

gagging was more rare. The wretched distress and intense suffering caused in man from obstruction, does not rise to such a degree in dogs. This fact is explained on the ground that vomiting from obstruction is from nervous irritation—reflex—and not from mere stoppage of fæcal circulation, or occlusion of the bowel lumen. A man's sensorium is indefinitely larger than a dog's, finer, and more delicate in fabrication, and capacity for reception is accompanied by more liability to disturbances. Also, the length of the canal is shorter, and dogs generally refuse to eat or drink in such condition.

*Experiment No. 48.*—Dog; male; weight, 35 lbs. Animal chloroformed and ilium drawn out of a two-inch median incision. A piece of alcohol gauze was thrust through the mesentery and tied with sufficient firmness to prevent fæcal, but not blood, circulation. It was cut short and dropped into the abdomen, and the cavity closed. The abdomen was reopened 60 hours after. The obstructed point was so difficult to find that the gut was passed through the fingers and before the eye. The gauze and the gut each side of the obstruction lay in a mass of inflammatory exudate and oozing lymph. The proximal gut was dilated with gas, and of a very dark red. The distal gut was collapsed and natural in color. The lymph and exudate was very extensive for sixty hours' action.

The dog had become infected, as pus appeared in the abdominal incision. The gut above and below

the obstruction was anastomosed with rubber rings, and omental graft applied. The dog died on the fourth day from peritonitis, an infection received purely from unclean operation and surroundings; a dog will resist one fairly unclean operation, but a second will generally end his existence. Autopsy showed that the anastomosis had healed perfectly, and the fæcal circulation was passing the new channel; the omental graft was firm in its adhesions; the alcoholized gauze had never been disturbed. This experiment clearly shows that our means of relief in anastomosis is amply sufficient, and that infection must be excluded by cleanliness. It is not always possible to be sufficiently clean in a barn, in abdominal work, though considerable precaution was exercised.

*Experiment No. 39.*—Dog; male; weight, 25 pounds. Animal chloroformed, belly shaved and small intestine drawn out of median incision, and strip of gauze soaked in alcohol and pushed through the mesentery and tied around the gut with sufficient firmness to check fæcal but not vascular circulation. This was done antiseptically. The abdomen was closed.

The dog was re-chloroformed 56 hours after and abdomen reopened. The cavity was pure and aseptic. Much difficulty was experienced in finding the obstruction, as one can not tell the difference in the feeling of a collapsed and a gas-distended gut. The obstruction was finally found and drawn out of the

incision. The bowel above the obstruction was much distended with gas and liquid stool. The band causing obstruction was completely buried in lymph and inflammatory exudate, but the peritoneum was healthy and clean. The bowel above and below the seat of occlusion was anastomosed with segmented rubber ring, introduced into incisions on the convex border of the gut. The proximal gut was highly distended with gas, and became emptied for 4 inches on incising it. It was deeply congested. The distal gut was natural in color, but extremely collapsed. The obstruction was left undisturbed. The six sutures which were passed from the gut lumen outward on each plate, were tied to each suture of the corresponding plate after the serous surface was scarified. A large omental graft (four layers) was stitched over the anastomosis and held in position by four sutures. The dog died on the fifth day from a fæcal fistula occurring at the joint of the rubber segment. This fault arose unpleasantly frequent with the rubber rings. On procuring four soft rubber tubes for the segment, it lessened in frequency. I am convinced also that experiments suggest to make the anastomosis 8 to 10 inches distant from the seat of obstruction on each side. Such a condition will allow more physiological and mechanical rest at the seat of occlusion. It appears that peristalsis is a sequence of the presence of fæcal matter, and if the fæcal circulation goes through a new channel, the peristalsis will also be confined to

that channel. However, it would leave the obstructed point in a less dangerous condition by cutting off its functions and vascularity, leaving it with nothing to do but to heal.

*Experiment No. 58.* — Foreign body; dog; weight 30 lbs. Animal chloroformed, belly shaved, and median incision made. The omentum was pushed to left and loop of small intestine drawn out. The bowel was incised on convex border for one inch. A piece of metal one-quarter of an inch in thickness, and twelve inches long, was bent on itself so as to measure six inches long and one inch wide. This was inserted in the bowel and the wound closed by a Czerny-Lembert suture. The dog was not disturbed in recovery. He was killed twelve days after foreign body had passed per rectum. The gut was narrowed one-half its original caliber at point where the foreign body was introduced. No fæcal accumulation resulted. No evil effect was observed on animal or its canal. How that larger, long, body passed the small valve of Bauhin is a puzzle. The normal valve would scarcely admit the tip of the little finger. In direct proportion, a man of 150 pounds, should pass a foreign body of six inches wide through the ileo-colic valve.

Other operations producing artificial obstruction were performed with about similar results. These experiments amply demonstrate that anastomosis as a means of relief in intestinal obstruction is reliable,

and under strict antiseptic precautions not a very dangerous operation. I think a dog is more susceptible to peritonitis than man, for the reason that a dog's peritoneum is more complicated, extensive, and vascular; but I attribute the fatal peritonitis in dogs to infection from uncleanliness, purely, as I never put a dressing on a dog, and the surroundings during the operation were not such that I could be aseptic.

I modified and re-classified the following table from Doliger:

INTESTINAL OBSTRUCTION—LOCATION, IN WALL, OUTSIDE WALL, IN LUMEN.

| | |
|---|---|
| I. By organic affections of the gut wall. | 1. Inflammatory stenosis.<br>2. Cicatrical stenosis.<br>3. Hypertrophic stenosis.<br>4. Valvular stenosis.<br>5. Polypoid stenosis.<br>6. Cancerous stenosis.<br>7. Ileus paralyticus. |
| II. By lesion of position of bowel wall. | 1. Invagination.<br>2. Torsion.<br>3. Flexion.<br>4. Volvulus.<br>5. Littre's hernia.<br>6. Traction over bands. |
| III. By strangulation. | 1. Internal hernias through diaphragm or abnormal openings in mesentery, etc.<br>2. Strangulation by ileo-cœcal appendix or intestinal diverticulum.<br>3. Strangulation by peritoneal bands.<br>4. Strangulation of intestine by intestine. |

**IV. Foreign bodies.**

1. Calculi { biliary. / intestinal.
2. Foreign bodies.
3. Intestinal worms.
4. Fæces.

**V. By external objects.**

1. Compression of viscera, kidney, uterus, etc.
2. Abdominal tumors and inflammatory products cause compression.
3. Lesions of central nervous system.

# CHAPTER XVII.

## RESECTION OF INTESTINE.

History seems to begin the record of intestinal resection from the suggestions of Dr. Littre, in 1710. Ramhdor has a record of removing two feet of gangrenous intestine in 1727; Cookesley, of removing six inches in 1731. Recorded operations followed at rare intervals by Reybard in 1844, Gussenbauer in 1877, Baum in 1878, Martin in 1869, and Czerny in 1880. Since 1880, the records of at least 150 resections are extant.

The following quaint paragraph from Cheseldon's Anatomy (London, 1730), as quoted by Smith, is interesting history:

Thomas Brayn, of Yeaton, in the Parish of Baschurch, and County of Salop, a doctor for cattle, maketh oath, that about ten or twelve years agone, he was sent for by a farmer, or husbandman, who lived near the village called Maesbrooks, and very near to the river Verney, in said County of Salap, to have his advice about an ox he had, which was then sick by reason he could not dung; he had been drenched by several beast doctors before this deponent came to him. This deponent, seeing this ox in the condition he was in, told the owner that if he would venture his ox, he would do what service he could in the curing of him, which the owner consented to, and thereupon this deponent opened the ox in the flank and took great part of his bowels, upon search-

ing which he found there was a perfect stoppage in the guts; and the gut was about the stoppage putrified for about three-quarters of a yard, whereupon this deponent cut off so much of the gut as was putrified, and took it quite away, and then drew the ends of the guts, which remained sound after what was cut off, together upon a hollow keck, which was about three or four inches long, and sewed the said ends of the guts together on said keck, leaving the keck within the guts, and then sewed up the hole cut in hide upon the flank of said ox; and deponent further saith, that within the space of one hour after this operation was performed, the ox dunged, and the piece of the keck which the said ends of the gut were sewen upon and left within the guts, came away from the ox with the dung, whereupon the ox recovered, and lived to do the owner service several years.

It may be stated in general that resection of intestine was put on a recognized basis by the great Langenbeck of Berlin, materially aided by Dr. Küster. The conditions which call for bowel resection are generally three—gangrene, malignant disease, and artificial anus. Formerly, stricture was another condition demanding resection, but to-day such a procedure would be considered unjustifiable, as with rubber plates, or any other suitable discs, the gut above and below the stricture could be safely anastomosed in fifteen minutes, leaving the stricture *in situ*.

*Experiment No. 67.*—Dog; pug; weight, 10 lbs. A loop of intestine was drawn out of in-

cision, and some two inches resected. The two divided ends were then invaginated, and closed with a few continuous sutures. The mesentery was tied in two parts before it was cut to remove the gut. Through incisions on the convex surface of the gut, raw-hide plates were introduced, and the distal and proximal bowels were anastomosed. The surface was scarified over the plates, which were coäpted, and the 6 sutures of one plate tied to the corresponding 6 of the other; omental graft, Dog killed 9 days after. All viscera appeared quite healthy; the graft had found firm adhesions. A notable point was observed here, in that the invaginated bowel-ends had continued to invaginate until the apex had passed beyond the artificial or bimucous fistula, thus endangering obstruction iu the anastomosis. The gut-ends were at first invaginated about one inch, and continued several inches. This should be avoided by only invaginating one-half inch, and thus giving no purchase power to the muscles to continue the invagination. The plates were gone, and fæcal circulation was perfect. The amputated stump of the mesentery had shrunk very much.

*Experiment No. 66.*—Dog; weight, 25 lbs. A loop of intestine was drawn out of a median abdominal incision, and 10 inches of the bowel resected, the divided ends invaginated one inch and so fixed with a few continuous sutures. The mesentery was separated, and tied in four bundles, and then the gut cut

away; finally, a ligature was applied around the whole mass. The precaution of tying the mesentery in small bundles, and then tying it in mass, arises from its tendency to shrink and bleed. The distal and proximal ends of the bowel were then anastomosed by inserting raw-hide plates through incisions in the convex surface, and approximating the plates, scarifying the surface, and coapting by tying the corresponding sutures. The whole anastomosis was covered by an omental graft, sutured in position. The dog made an excellent recovery, and ran away in ten days.

*Experiment No. 68.*—Dog; weight, 30 lbs. The small intestine was severed 8 inches apart, and the 8 inches of gut resected and the mesentery well tied in small bundles; the bowel ends invaginated and sutured; the distal and proximal bowel ends were amastomosed with rawhide plates, and graft applied.

Dog died 40 hours after from fæcal fistula, arising from improperly tying the plates together. One thread slipped after the knot was tied, causing a fistula and death.

*Experiment No. 90.*—Dog; weight, 12 lbs. The ileum was drawn out of abdominal incision and 6 inches of gut resected; the mesentery was tied with two sutures. The divided ends were united with a continuous suture; omental graft applied. Was sick the first two days, then again the eighth and ninth, but recovered well.

We removed a few inches several times in other operations, but no evil effect followed. It was shown in the experiments that dogs recovered without severe symptoms when from a few inches to a foot and a half was removed, but above this the shock seems in proportion to the amount resected. All are familiar with Koeberle's celebrated case when he resected some 6 feet with recovery. Other surgeons have resected 4 feet, and recovery occurred. Our animal experiments show that exclusion of a few feet of gut from digestion often is accompanied by severe marasmus. I have seen dogs weighing 25 pounds lose half a pound daily while eating voraciously. In fact, it keeps such dogs eating, while the stool is liquid and frequent. Resection of a gut gives more shock to an animal than the physiological exclusion of the same length of bowel, in a geometrical ratio. Dr. Senn states that resection of 6 feet is fatal, and 4 feet is incompatible with normal digestion. Experiments in resection in animals speak very impressively. A dog with a long piece of gut resected, lies in profound shock from trauma. A 2-foot resection (equal to 4 feet in man) highly affects a dog. In resection, care must be exercised that no bowel is left without mesentery with acting blood-vessel in it. The large vessels in the mesentery must be ligated with care, so that gangrene will not ensue. Several dogs died from gangrene where a bullet had lacerated the mesentery close to the gut wall. I think it is a very

practical idea to sew up the rent in the mesentery, so that it will not act as as aperture to strangulate some knuckle of bowel. In resecting for gangrene every particle of bowel wall should be removed. No mucous surface should be left as it would secrete in to the peritoneal cavity. To prevent fæcal extravasation, small pieces of rubber band can be thrust by a blunt forceps through the mesentery, and tied around the gut sufficiently firm to prevent leakage without doing damage to the bowel.

In resecting a piece of gut it is practical to sever the gut between two large blood vessels in the mesentery and after the gut is completely cut off, to tear the mesentery, as it will not bleed so much from tearing as cutting. By holding the mesentery so that the light will pass through it, the large blood vessels can be easily seen and avoided. Some dogs died from gangrene, causen by ligating a trunk of a mesenteric vessel. Gangrene occurred in 48 hours, and death inevitably followed. In one dog, gangrene arose in 30 hours from tying a large mesenteric vessel on the edge of a torn mesentery. Resection should never be practiced for non-malignant stricture, but for malignant cases it will often prolong life, yet in about 25 per cent. the carcinomatous growth will be found disseminated in the liver and other glands along the highway of nutrition. A non-malignant growth, such as a bleeding polypus may demand operation.

The bowel might be incised on the convex side

and closed, and then anastomosed from above, and below the point. For it should be remembered that as soon as the fæcal circulation pressure is removed the disturbance at the seat of the trouble ceases. In the same way an irreducible and even gangrenous intussusception at the apex could be left in position while the proximal and distal gut were anastomosed, for atrophy quickly assumes sway in the physiologically excluded loop. Peristalsis will almost cease unless some fæces accidentally enter the loop. A mass of intestines, large or small, when found matted together, scarcely ever demand resection, but the coils should be left undisturbed and the gut of entrance and exit should be found, and their lumen above and below the adherent mass anastomosed. With proper plates for anastomosis in the intestinal field, resection will become more and more restricted to two conditions, viz; gangrene or malignant growth. I do not think it necessary or even advisable to resect a triangular V shave part of the mesentery. My experience on animals is to resect as little as possible and to exercise great care in tying large trunks for fear of gangrene.

I would distinctly call attention to the closing of invaginated ends. Several dogs have died from infection derived from this source. One died because the end dis-invaginated and poured its contents into the peritoneum. Another died from fæcal fistula caused by the stitch passing too deep in the bowel wall.

Another died from gangrene of the mesentery, at the seat of invagination, caused by tying the trunk of a mesenteric artery. The gut to be invaginated should be seized between the finger and thumb of the left hand, and the right hand should seize both edges of the severed gut with toothed forceps. The forceps with the two edges of the gut should then be pushed steadily into the bowel lumen, for about ½ inch. A needle should then be passed through the gut-wall only as far as the under surface of the aponeurosis—not through the mucous membrane. The needle should then enter the cone-shaped mesentery, and again pass in the gut-wall to the under surface of the aponeurosis on the other side. This includes a Lembert stitch, with the mesentery in the middle, penetrated by the needle. This first stitch tied, now holds the invaginated end fixed. Two to four more should be employed, continuous or interrupted. It is not generally necessary to put a graft over it, but it is safest and best to scarify the sutured end and apply a small, severed, omental graft to it. The suture through the mentery is a distinct feature in the case.

The most extensive and accurate statistics on resection are given by Reichel up to 1883. He gives one hundred and twenty-one cases. Fifty-eight of these cases died, and fifty eight recovered, and five recovered with a permanent fæcal fistula.

Since that date, statistics, recorded, show better

percentage of recovery, yet the unrecorded cases, which are almost always fatal, are quite numerous. We point with pride and growing hope to the fact that animal experimentation has introduced and perfected intestinal anastomosis, which will almost entirely displace intestinal resection, except for gangrene and malignant neoplesms. In the introduction of anastomosing the intestines by perforated approximating plates, Dr. Connell and Prof. Senn have proved themselves benefactors to mankind. Since these resections were done, we have resected some half dozen more cases in performing different operations on the intestines, but as similar results followed, it is unnecessary to record them.

# CHAPTER XVIII.

## GASTROSTOMY.

The term gastrostomy was introduced into medicine by Dr. J. H. Pooley, of Toledo.

The operation of gastrostomy was first advocated by Dr. Egebert, in 1837. He was a Norwegian military surgeon, and received the idea from the natural existence of gastric fistula, as being compatible with life.

Dr. Sedillot, however, first performed the operation in 1839. Watson, Streubel, Fenger, Nélaton, Forster, Günther, Gross, Curling, Küster, Bryant, Jones, and Howe, have all advocated the operation. Dr. Zesas, wrote a splendid monograph on the subject in 1885. The operation can by done in one or two stages. The operation in two stages consists in first suturing the stomach to the walls of the abdomen, and then opening it in a few days after. The other operation consists in fixing the stomach and opening its walls both at the same time. The object of the operation is to establish a fistula between the lumen of the stomach and the world. The fistula will pass through the stomach and abdominal walls. The demand for the operation consists in some obstruction in the alimentary tract from the mouth to the stomach, which prevents the passage of foods. These obstructions may be malignant or non-malig-

nant growths, cicatricial tissue ulcers, destruction of parts or congenital malformations. Space forbids discussion of the subject, but some 400 recorded cases are at present extant. The operation suffers from having to be done on cases of malignant growths, and are generally too late to do much good. For non-malignant obstruction, good results should follow. One experiment, will be sufficient to demonstrate the operation, and it is best done with segmented rubber plates, or rings, or raw-hide plates.

*Experiment No. 44.*—Dog; weight 10 lbs. Animal chloroformed, abdomen shaved and opened in median incision for four inches beginning at xiphoid cartilage.

The index and middle fingers were introduced, and a fold of stomach drawn out between them. The stomach wall was incised with scissors for an inch and a half, through the serous and muscular coats. The mucous coat jutted out and through the wound as if too large for its position. A still longer incision was made in this coat. Bleeding was slight in incisions. A six segmented rubber tube ring held together by four strands of raw hide and armed with six sutures and six round needles was inserted into the stomach. The six needles were then pushed from inside the stomach through its whole wall ¼ inch from the margin of the incised wound. These same six needles were then passed through the abdominal wall and then drawn tight. This action fixed the

ring against the mucous membrane of the stomach and co-apted the stomach (serous) wall against the internal abdominal parietes. The six sutures were then tied two by two. The stomach wall, and especially the mucous membrane, was carefully sutured to the median abdominal incision, which was closed except the orifice corresponding to the stomach. The dog made an uninterrupted recovery. He played, ate and drank. When the dog ate food or drank fluid it immediately flowed out of the wound in the abdomen to such a degree that it kept him hungry. The poor fellow was hungry a few minutes after eating a good liquid meal. So he ate with a continued vehemence characteristic of a determination to keep food in his stomach if it took all summer to fight it out on that line of voracious appetite. Even with this dog's unequalled energy in consuming food he became a sufferer from marasmus.

This dog had recovered from a circular enterorrhaphy of some three weeks previously, and therefore was bearing the brunt of two operations in one month.

Dog killed about ten days after. Abdominal organs were all healthy except some old adhesions which showed the rise and fall of a peritonitis. The fistula in the stomach and abdominal wall, showed a sphincter-like condition, admitting the index finger; it had contracted two-thirds to three-fourths of its original size. The stomach, at the autopsy, showed itself to be contracted to a mere tube. It had never

been dilated since the operation. If a rubber in the shape of an hour-glass had been put in the opening, and then blown full with air after the liquid food was injected into the stomach, the dog would live almost as well as ever. The fluid which trickled over the abdominal wall excoriated the skin. In doing this operation, with a little practice, one can secure a flap valve at the stomachic incision, which will prevent the excessive outflow of fluids by the flap folding over and closing the aperture after injecting the food. In man the flap should be on the lower margin of the incision.

# CHAPTER XIX.

## JOBERT'S OPERATION.—AUTHOR'S MODIFIED JOBERT.

Anyone who experiments very much with the operation of circular enterorrhaphy quickly finds out its dangers. To unite the circular divided bowel ends, one uses a Czerny stitch (which acts just as well continuous as interrupted in some cases). The next suture should be the Lembert, and it requires from eighteen to thirty of these to close the bowel sufficiently. It is not strange that an operator should penetrate the mucous membrane in applying a needle thirty to forty times, and thus cause fæcal fistula. It cannot be wondered at that in tying so many sutures, in such delicate tissues, a few of them should become too tight, and thus cause gangrene and sloughing. It is also quite apparent that considerable time is consumed in applying thirty or forty sutures. Hence time, gangrene, and fæcal fistula play a rôle in the operation.

To obviate some of these difficulties, I experimented with different methods. One of the first tried was to invaginate the distal bowel end, and then insert the proximal end into it, about one-half inch; after which, applying the Lembert sutures in a circular manner, with scarification. This produced excellent condition for healing, and I thought it

would be a good operation, as I employed no invagination suture. The invagination sutures possess a certain degree of danger, whether of silk or catgut, as they pierce the gut-wall. The healing results were remarkably good—but the invaginated end continues to invaginate, and endangers the animal's life. From this cause some died.

If any one will suggest a safe method to prevent the continuous invagination of the distal bowel, the operation of circular suturing will be, without the invagination sutures, the safest surgical procedure in the whole field of intestinal work. I have not known of any experiments previously done in this direction to demonstrate the features of invagination. In vain I have searched all available literature to find if other experimentors have had similar results relative to this subject, but could find no records and yet I cannot he mistaken, for I have done all my own post mortems, and found this peculiar form of invagination which has gone fatally forward after the operation. Dis-invagination occurs very seldom with Lembert sutures, yet it must be provided for as it actually occurred, and proved fatal in experiment. Progressive invagination after operation might be inhibited by suturing the bowel an inch above and an inch below the operation to the abdominal wall, but it would likely rupture the sutures. Another method was tried which proved in many ways a success, and I think it will be a good method without invagination

sutures. A rubber tube about two to three inches long and varying in size according to the lumen of the bowel was stitched into the point of invagination at its middle, so that an inch or such a matter projected above and below the united parts. This proved the most useful of all contrivances. We tried all kinds of rubber rings according to Dr. Senn, but results were best with the rubber tube.

Now we believe with this rubber tube, and the distal bowel invaginated only one-half inch, and the proximal bowel pushed into the distal an inch, that circular suturing with Lembert stitch will be amply sufficient to produce good results, entirely avoiding invagination sutures. When a bowel is only invaginated one-half inch, it gives the muscles of the gut no purchase power to continue the invagination. The operation can be done in a short time. One fault is to be found with Jobert's operation and all its modifications, and that is, the amount of manipulation required to be certain of the direction of the gut.

Here we can speak of the test which Prof. Nothnagle, of Vienna, discovered, while experimenting upon the intestines of animals, and has since advocated. He claims that when a potassium salt is brought in contact with the serous surface of the bowel, a circular constriction takes place. This I verified by experimentation. The circular constriction arising in the bowel of a dog by the application of a little chlorate of potash is remarkable. The lumen

of the gut will occasionally be narrowed to the size of a crow quill. The muscular contraction at the seat of application resembles a pale, white, bloodless, band constricted around the bowel. The steady, tonic, muscular contraction persists for some time.

The other test of Prof. Nothnagle is that when a sodium salt is applied to the peritoneal surface of the bowel an ascending peristalsis occurs. We carefully experimented on this subject, but could not verify it. The application of a little table salt to the exposed gut made a circular constriction, but very much less active than the potassium salt. Slight muscular quiverings could be observed in the gut a little more toward the stomach than occurred in the application of a potassium salt, but in no case did it demonstrate sufficiently to enable one to detect the direction of the bowel. I have never seen it tested on a human being, but if it could demonstrate the direction of the bowel in man, it would become an invaluable test in doing quite a number of operations, such as Jobert's and the author's.

I have particularly noticed that surgeons disagree as to the correctness of Dr. Nothnagle's two tests. The test which I used was to find the cœcum first. An idea has been brought forward that the invagination in Jobert's operation will cause gangrene, just as it does in any form of invagination. It seems to the writer that the analogy between Jobert's and any other invagination is entirely dissimilar and un-

like. The very cause of gangrene in ordinary invagination does not exist in Jobert's, which is a connection between the intussusceptum and intussusscipiens. Here is where the sausage-like tumor and the knob of œdema arise, at the point most distant from the obstruction—in the location of the least resistance to fluid collections. The connection between the intussusceptum and the intussuscipiens in Jobert's operation is entirely severed, and therefore no œdemetous tumors or knobs can collect. No venous blood can be dammed up or shut off, and no gangrene can occur without the obstruction of venous blood. So far, I have never seen a single case of gangrene in Jobert's operation. Again, in ordinary invagination the mesenteric vessels are carried in to the invaginated parts. Here the entering and returning gut—the intussusceptum—forms a distinct arch, with a tight constriction at each end. The entering point is tightly compressed by constriction on the mesentery, and only allows blood to pass through the thick, rigid, arterial walls into the arch, but will not allow blood to return through the joint of compressed mesenterial, thin-walled veins. In this manner the venous blood begins to collect on the side of the entering gut.

At the point of exit, or at the neck of the intussusception, the pathology is still more apparent. The neck is generally so constricted that it will scarcely permit the entrance of even arterial blood into the arch, but in swollen inflamed conditions the venous

blood has but little chance to pass out of the arch through the neck. In this manner venous blood is obstructed at both ends of the arch, and collects in the most distant points from the obstruction—points of entrance or exit—which is also the location of least resistance to fluid collections. No connection, of contiguous arch of blood-vessels, exists between the intussusceptum and intuscipiens in Jobert's operation, and therefore no fluid collection can occur. In doing Jobert's operation, as I suggested, without invagination sutures, and with a rubber tube about the size of the gut and two to three inches long, it can be observed; there being no vascular conection between the invaginated parts, no fear need be entertained of venous stasis in circular suturing. In such an operation, five or eight Lembert (interrupted) sutures will suffice.

The difficulties encountered in doing Jobert's operation in a small-calibred tube, are at first quite considerable, but with a little practice most of the cbstacles disappear, and with acquired skill, one wonders why it was so difficult at first; but many of the real difficulties are overcome by the use of the rubber tube, which acts as a guide.

Dr. Gross experimented on the intestines of 70 dogs from 1841 to 1843, and published a treatise on the results. It shows well the persistent efforts of a remarkable man to progress even with no anæsthetics. He performed two Jobert operations, but one dog

died on the third day from peritonitis, and the other on the eighth day from obstruction at the point of operation. He had such difficulty in performing the operation, and such fatal results, that he unsparingly condemns it with but two trials, and says:

Independently of their unfavorable termination, the difficulty which attended their execution would be enough to deter me, under any circumstances, from resorting to it in the human subject. A practitioner may err through ignorance, but when he does so, designed by or despite the most abundant light, neither his own conscience nor the voice of the profession will excuse him.

This shows the sentiment of an able, original man of 50 years ago; but modern experiments demonstrate that with improved methods Jobert's operation does not deserve such wholesale condemnation. To do Jobert's operation, one severs the gut completely, and invaginates the lower bowel end half an inch with a pair of forceps. Then a needle armed with a thread is passed through the proximal bowel about half an inch from the margin of the wound. Another needle is put on the other end of the same thread. At a point opposite to this suture in the bowel another similar thread is inserted. Now the four needles (with two threads) are passed from within out through the two bowel walls. These invagination sutures are then drawn tight, when the proximal end will pass into the distal end, where they are fixed by tying the sutures. Some Lembert sutures can be applied to

add strength, and a graft should be applied and sutured in position. The addition of the rubber tube increases the safety of the operation very much. The invagination sutures should be fine catgut.

The following four operations were all I did exactly according to Jobert, with the exception of the addition of the rubber tube and Lembert sutures. The experiments will explain themselves. The reason I did not make more numerous experiments with Jobert's operation was, the belief that a modification of it would prove more certain in saving life. The invagination sutures are dangerous.

*Experiment No. 135.*—Dog; weight, 25 lbs. A loop of intestine was drawn out, its direction determined and completely divided. The distal tube was invaginated, and linen invagination sutures passed through the both extremities. Then while the invagination was being done, the invagination sutures were drawn tight and tied; a few Lembert sutures were added to strengthen it, and a graft was applied. In this case I began using a one-eighth inch rubber tube, two to three inches long, stitched to the edge of the proximal gut end.

The dog died in three days from fæcal fistula at the site of the invagination sutures. The tube kept the gut lumen patent. It is an improvement. The invagination sutures are dangerous, and especially when unabsorbable.

*Experiment No. 137.* — Dog; weight, 30 lbs.

Abdomen opened and the standard by which the direction of the bowel is determined, is the cœcum, so that is first sought and intestine divided. The distal end was invaginated one inch. Two catgut invagination sutures were applied by passing the needle on one end of the suture through the proximal bowel end. Another suture was passed on the opposite circumference of the divided gut edge one-third inch from the margin. One of the invagination sutures was passed through a portion of the wall of the rubber tube, so as to retain it in position. The four needles were then passed through the two layers of gut in the distal extremity, the two needles belonging to the same thread were passed through the gut layers close together. The invagination sutures were drawn tight, and the distal received the proximal extremity. After tying the sutures a few Lembert sutures were applied as well as a graft, unsevered and sutured in position. The dog did well for five days, when he became involved in a fight, and his belly was torn open at the point where it was sutured. His intestines trailed in the dirt and he died in 18 hours. He was recovering nicely, and drank, and played. Autopsy showed that the operation was healing nicely in fact was almost beyond any ordinary danger. The rubber tube seems to be very adaptable, and the essential to the safety of Jobert's operation. The repair in the gut demonstrated to me that the invagination sutures should be of fine, cat-gut, and

passed quite close together on opposite points of the circumference of the bowel. The graft was very firm and adhesive, and appears to me to be the main safeguard in the operation. Two invagination sutures seemed to be sufficient if strengthened by a few Lembert's sutures, applied around the circumference of the conjoined bowels.

*Experiment No. 139.*—Bitch; weight, 18 lbs. A loop of intestine was drawn out, the cœcum found to decide its direction, and then completely divided. The distal extremity was invaginated ¾-inch, and proximal inserted into it, and rubber tube 1½ inches long was fixed in the proximal end with a stitch. Two invagination sutures were used, of fine catgut. A graft was well applied, so that it snugly coapted the circular wound. A few Lembert sutures were placed to add security to the two invagination sutures.

The dog was scarcely sick, and ate and drank well from the second day. Seven days after, the dog was as lively as ever, and made so much noise that I killed her with chloroform. The outside of the Jobert operation showed a remarkable condition. The graft applied was large. At each point of the invagination suture the catgut had made two fistulæ which looked as if they had been cut with a punch one-eighth inch in diameter. These two little holes led out of the gut into two excavations or abscesses in the graft about as large as an ordinary pea. The fæcal matter which had escaped was very small, but

it had irritated the omental graft and caused so much inflammation that the omental tissue was thickened almost ten times its original. In seven days, inflammatory products had thickened the tissue into bunches more than ¼-inch thick. The tissue at one point was as large as a plum, and this enlargement appeared to narrow the tube. The whole graft was involved in this new proliferation of tissue. The dog ate, drank, and played, and appeared perfectly well, from the third day; he would not likely suffer any subsequent trouble from the operation. The Lembert sutures were still intact, buried in the graft. There is apparrent danger in any operation accompanied with invagination sutures, as they penetrate the whole thickness of the bowel wall, and the fæcal matter and gas follows the suture out iuto the peritoneal cavity. Again, the suture acts as a drain tube, with capillary attraction, to carry infection into the great lymph sac, the peritoneum.

*Experiment No. 138.*—Dog; weight, 15 lbs. Abdomen opened and cœcum found to determine the direction of the tube. It was completely severed; the distal end invaginated an inch. Two catgut invagination sutures were used, and the proximal gut end inserted into the distal one inch. The invagination sutures were tied, and a few Lembert sutures added. An omental graft was carefully coäpted to the scarified wound and sutured with three sutures. The dog only took water the first week;

the second he ate well. The rubber tube in this case was ⅛ inch in diameter and two inches long. One of the invagination sutures were passed through a portion of its wall to hold it in its place. He was killed fifteen days after the operation. There was considerable thickening of the gut at the operated parts. The graft was firmly and solidly healed. The invagination sutures were absorbed. The rubber tube had passed per rectum. Invagination sutures are easily demonstrated to be dangerous on account of the large amount of pathological change found at their seat. In every autopsy very great pathological changes were observed, showing that considerable inflammation, exudation, and cell proliferation had occurred.

THE AUTHOR'S OPERATION.

This operation on the intestines is original with me. I have, since conceiving and performing it, looked in vain for records of any suggestion of it. The rising of a great hope is like the rising of a sun. It is with pleasure akin to this that I present this new operation to the profession, with the hope that it may prove useful. All intestinal operations are accompanied with a mortality sufficiently appalling, and the writer hopes by adding his mite that the surgery of the intestines may be bettered, even if it be but in a slight degree. I have confidentially indulged the hope that the experiments and suggestions contained in this little

book will stimulate others with better minds and opportunities to do original work, that they will call forth enough criticism to caution men to sift the good from the bad, and use that good to lessen suffering and prolong useful lives. This operation may be rejected or cultivated by men according as future trials shall determine its value. Allow the author a suggestion. Be sure to become familiar with the operation before it is condemned or lauded. Improperly done it is a failure. It is like Prof. Senn's hydrogen gas test. Many otherwise accomplished surgeons attempt to use the gas test on a human patient—the first time the surgeon has ever tried it. Is it a wonder that the surgeon fails and says "It's no good?" We wish to say that *repeated* experiments make this gas test a valuable diagnostic agent. Dr. Senn says in 100 times he makes no failure; and so it is with this operation. To make it a success the mucous membrane must be accurately and totally removed, for from ½ to 1 inch of the distal bowel end. The serous surface of the proximal bowel end should be well scarified. The mesentery should be torn off for the length of bowel desired to be inserted into the distal. A rubber tube of diameter sufficient to fit the bowel loosely, should be sutured into the proximal gut end. The rubber tube should be about three inches long. After the proximal bowel is inserted into the distal, the needle passes through the distal bowel wall and through the serous and muscular coats of the prox-

imal gut wall, down to the mucous membrane, and then returns as a Lembert suture. The distal bowel edge should be stitched to the proximal bowel wall by circular, interrupted suturing. Interrupted sutures are, in the main, the safest in the bowels. A graft should be well fitted to the entire circumference of the intestine, and held in position by several sutures; both graft and serous surface should be scarified with the needle point. Of course it is needless to say that the success of the operation will depend on the direction of the gut being determined before the operation is done.

The following eight cases were typical experiments. More work was done, but not recorded here. It will be noticed that there are really but few deaths from the operation. Two out of three dogs that died did not die from the operation., but from accidenst accompanying it, *e. g.*, hæmorrhage, and from an old peritonitis reinforced. The other died from pure failure of the operation—fæcal fistula.

The cases will illustrate the *technique* of the operation.

*Experiment No. 142.*—This dog had been shot, and laparotomy performed 28 days previously. The rubber plates were gone, but a slight inflammatory condition of the omentum was found on the second laparotomy. The direction of the gut was first determined by finding the cœcum. Fifteen inches from the latter it was severed, and a rubber tube (3

inches long and ¼ inch diameter) inserted in the proximal end and held in position by a suture passed through the tube and the marginal end of the bowel. Then ¼ inch of the mucous membrane of the upper end of the distal bowel was dissected off with the scissors. The proximal bowel end, with the rubber tube in it, was then inserted into the distal end. The distal gut was drawn over the scarified proximal end for ¾ of an inch, and sutured in position by ten to swelve stitches, most of them continuous. The sutures pass entirely through the distal bowel end whose mncous membrane was cut away, and passed into the proximal bowel end as a Lembert suture.

The dog died on the third day. The autopsy demonstrated that the wound was healing nicely. The scarification had laid the essential foundation for successful healing. I noticed three red joints on the mucous membrane of the proximal gut when the needles had penetrated too deep in taking a Lembert stitch, but they were healed. The post-mortem showed about the best example I had ever seen of progressive fibro-purulent peritonitis. Nature had made an effort to encapsulate the pus, and even succeeded in some parts. The old fibrin pockets of exhausted pus, and the puddles of pus surrounded by flaky layers of pyogenic membrane and new exudates of fibrin, showed partial success. But the destruction of vitality caused by the second laparotomy overcame Nature's resistance to disease, and killed the dog.

The operation was not the cause of death, but an infection causing a progressive fibro-purulent peritonitis.

*Experiment No. 143.*—Dog; weight, 75 lbs. The dissection of gut found by locating the cœcum. The bowel was severed 18 inches from cœcum. The mucous membrane was dissected off for three-fourths of an inch on thedistal gut. The proximal bowel end was scarified and inserted into the lower gut, after a rubber tube had been stitched in proximal end. The bowel with the mucous membrane dissected off was sutured to the scarified serous membrane. Several sutures were taken and then interrupted and tied until the whole bowel circumference was completed.

Twenty-four hours after the dog acted well, and ate and drank. Fifteen days after, when seen, he was well and happy. A graft was applied so as to snuggly fit the whole circular wound. Twenty-three days after the operation, the dog was shot through the abdomen—anterior-posterior—while he was standing on his hind feet. No operation was performed on him, and he died in about thirty minutes from hæmorrhage. Autopsy revealed the old operation well healed. The graft had grown firm and solid. It was real cell-proliferation, as the graft would not separate from the parts. The gut was narrowed just the thickness of the bowel-wall, probably one-seventh of its lumen. But little difference was felt in passing the finger in the operated parts, than in other parts of the gut. The proximal gut-edge had everted itself

after it had been inserted, and a rounded margin of bowel was found projected into the gut lumen. Whether this would atrophy, or absorb away, time alone would tell. It was a perfect recovery.

An enterolith of hay, straw, and hair had collected above the wound. Why this had collected here could only be explained by excessive peritonitis, as the gut-lumen was only narrowed from one-sixth to one-seventh its original lumen. However, dogs are quite subject to enteroliths. Liquid stool was passing continuously, and the dog was eating heartily and playing briskly. The enterolith would not kill in such cases, as the hay and straw would dissolve and pass itself as a liquid stool. The tube of rubber was gone, and only a few linen sutures were found on the mesenteric side of the bowel. The dangerous side of the bowel in most all intestinal operations is on the mesenteric side, because autopsies show that the most extensive pathology exists there, and pathological processes remain there the longest.

*Experiment No. 145.*—Bitch; weight, 10 lbs. The direction of small bowel determined, and the gut cut across. Mucous membrane dissected off distal end. A rubber tube (2½ by ¼ inches) was stitched in the proximal end, and it was passed into the distal bowel and sutured there. Denuded gut-wall was coapted to scarified mucous surface. A graft was applied so that it closely approximated the circular wound; three sutures held it in position.

Dog died in 48 hours from two causes perfectly avoidable. The autopsy demonstrated that the proximal gut was not invaginated far enough into the distal; and second, the mucous membrane was not wholly removed. The mucous glands must all be thoroughly removed, so that their secretions will not prevent healing. Death was due to leakage at point of operation.

*Experiment No. 147.*—Dog; weight, 9 lbs. A loop of intestine was drawn out, and direction determined and cut across. Mucous membrane cut off the distal bowel ¾-inch, and rubber tube (3 inches long by ¼ inch diameter) was stitched in proximal end. Its serous surface was scarified and inserted into the distal end, and sutured in position by a continuous Lembert suture, which passed through the entire wall of the distal bowel (minus the mucous membrane) and also through serous muscular and fibrous lamella of proximal gut wall. A graft was closely applied, and sutured in position by 3 sutures. I never saw any difference with this dog, relative to drinking and eating and playing, until the seventh day after the operation. He ate just as heartily the day after the operation as he did the day before. On the seventh day he did not eat so well, and being curious to know what was the matter, I chloroformed him to death. The autopsy showed an enterolith above the seat of operation, caused by two pieces of coal which he had eaten, all

wound up in a bundle of hay and straw. One piece of coal was 1 × 1¼ inch, and the other less. How that 9-pound dog swallowed that, was a puzzle. It caused three ulcers of the mucous membrane at the seat of the partial obstruction; one was ¾-inch long, quite deep, from the sharp edge of the coal. The gut was not obstructed to any ordinary object; it was probably narrowed one-quarter of its calibre, and would not be so much as that after the œdema had disappeared.

I have found dogs very liable to the accumulations of debris known as enteroliths. They will eat so much straw, hay and shreds in searching after food, and in playing. The bowel was dilated above the partial obstruction from simple accumulation. The graft was firm and solid. The wound had healed perfectly. The dog was young and the peritoneum, for one to two inches adjacent to the operated parts, was three to five times the ordinary thickness, from cell proliferation forming new tissue. The threads were disappearing by falling into the gut lumen. In healing the proximal cut had everted and rolled back some, to which was mainly due the narrowing of the bowel calibre. The autopsies showed that the rubber tube was the salvation of life in these operations. It prevented closure and subsequent invagination. The part of the gut which projects into the bowel lumen had atrophied some, but would require a long time to disappear completely. It did

not disappear as soon as one would expect, as its mesentery was torn off before invaginating. The abdominal organs were healthy.

*Experiment No. 146.*—Bitch; weight, 25 lbs. The direction of a loop of intestine was discovered, and the gut severed completely. The mucous membrane was dissected with scissors for three-quarters of an inch from the distal gut end. A rubber tube was stitched in the proximal end, and its serous surface scarified and inserted into the distal, and sutured as usual in position. A graft was applied and held in position by three stitches. This bitch had just had pups, and was anæmic and weak. She lost a large quantity of blood from the abdominal incision, on account of the fluxion of blood to the mammary glands, which were congested with blood. The wound, curiously, bled for fifteen hours and the dog died of exhaustion, shock and hæmorrhage, in 36 hours.

Autopsy showed the abdominal cavity free from inflammation. The intestines were of a very pale yellow color. All organs were anæmic and pale. The remains of the zonular placenta showed delivery had occurred probably a week before. The graft had nicely grown to the bowel. The wound was hermetically sealed, and was healing excellently and perfectly. The dog died of shock and hæmorrhage, and not from the intestinal wound. Seven placental zones were found in the tubes. This death from hæmor-

rhage, on an already anæmic animal, teaches us to be sure to stop bleeding vessels going to an organ, taking upon itself temporary function. Such rising temporary functions in organs, *e. g.*, the mammæ, have a remarkable determination of vascular influx, and if their vessels are cut and not ligated, they will often continue to bleed like vaginal lupus—which, when it starts, no man knows when it will stop.

*Experiment No. 151.*—Bitch; weight 15 lbs. The abdomen being opened the cœcum found, and tube's direction determined, it was completely severed. The mucous membrane was dissected from the distal end ¾ inch. A rubber tube ⅓ inch diameter and 2 inches long was stitched in the proximal gut with one suture. An inch of the serous surface was scarified and introduced into the distal tube for an inch, and held in position by a continuous suture around the entire circumference of the tube. We got better results as we assumed more care in tearing the mesentery from the proximal gut end, for a distance equal to the length of tube invaginated; also the best graft applied by securing uninterrupted co-aptation for the entire circumference of a scarified surface. The graft should be held in position by a suture through its mesenteric border and one fine stitch on each side of the circular gut wound on the convex portion of the bowel wall. The dog ate on the third day and since has seemed well and happy.

Ten days after the operation the dog was sacrificed to secure specimen. The wound had healed nicely. The graft had formed firm and solid adhesions, so strong, that in separating them, the gut wall would tear. The rubber tube had disappeared. The stitches had not yet dropped into the gut lumen. Continuous sutures were used for four to six sutures and then interrupted, and thus repeated until the entire circumserence of the gut was completed. I am convinced that the interrupted suture is best. The pathology that occurs in this operation is apt to take place, if at all, on the mesenteric side. It does not form such extensive adhesions as some other operations. The lumen of the tube was not narrowed. The healing between the bowel walls was very firm.

*Experiment No. 156.*—Bitch; weight, 6 lbs. The tube was severed after its direction was determined. The mucous membrane was dissected away. A rubber tube ¼ inch in diameter and two inches long was stitched in the proximal gut. Its serous surface was well abraded, and it was inserted into the distal tube. Good results were obtained by turning in or inverting a very slight amount of the distal gut end as a continuous suture was applied. A graft was well applied and sutured. The dog was sick three days, when she began to eat. This dog drank from the first day; she made an excellent recovery, eating, drinking, and playing.

She is, at writing, living as a pet with a family, and doing well.

*Experiment No. 150.*—Bitch; weight, 8 lbs. Abdomen opened and cœcum located by which the direction of the gut was determined. The tube was completely severed to the edge of the mesentery, after which we tore the mesentery to prevent continuous bleeding. The mucous membrane was well dissected from the distal gut for ¾ of an inch. A very soft ¼-inch rubber tube two inches long was stitched in the end of the proximal tube, and its serous surface scarified for ¾ inch. It was then inserted into the distal end, and sutured in position by circular stitches, which were interrupted three or four times in the circuit of the tube. The needle passed through the gut stripped of its mucous membrane, and down to the mucous membrane of the proximal gut. She was sick for two days, after which she eat vigorously, drank, and played. A graft was carefully applied and sutured in position fourteen days after, she having recovered. The experiment of abdominal shooting with no laparotomy was tried. She died in about thirty minutes. Autopsy showed the old wound healed well. The growth of the graft was perfect. It hermetically sealed the wound. The gut was narrowed in its lumen probably. However, the results appeared perfect in all respects. The stitches were fast dropping into the bowel lumen, and the pathology on the usual mesenteric side was quite limited, in fact, had almost disappeared.

JOBERT'S OPERATION MODIFIED BY THE AUTHOR.

Reference was made to dangers of invagination sutures when cultivating Jobert's operation. This suggested to me the idea of doing Jobert's operation without any invagination sutures.

*Experiment No. 133.*—Bitch; weight, 17 lbs. A loop of intestine was drawn out and its direction ascertained by the cœcum as a standard or landmark. The distal end was invaginated an inch by seizing the two edges of the bowel with a tooth forceps and forcing it into the lumen. The proximal end was then inserted 1 inch, and sutured in position by eight Lembert sutures. A graft was applied. The dog did well for four days, eating and drinking almost without interruption. She then became sick, and died on the fifth day. The autopsy showed dilitation of the proximal gut and complete obstruction at the seat of operation. The occlusion was caused by a progressive invagination of the distal bowel end, which had continued 3½ inches. The continued invagination had closed the bowel lumen by inversion of the divided bowel end. The gut was very much dilated above the obstruction. This operation had no rubber tube nor invagination sutures. The tube is essential to the safety and success of Jobert's operation, and it should pretty fairly fill the gut lumen. I am inclined to think if the tube was in the invagination, sutures would not be required. The healing was good, for

the dog ate well two out of four days, and the death was wholly due to obstruction.

*Experiment No. 134.*—Bitch; weight, 10 lbs. Out of a small incision in the linea alba, a loop of intestine was drawn and completely divided with the scissors, and to avoid bleeding from mesenteric vessels, the mesentery was torn from the edge of the gut to the desired distance. In this case no attention was paid to the direction of the bowel. The supposed distal extremity was invaginated, and its internal serous surface slightly scarified. The proximal end was inserted into the distal, and fixed in position by eight interrupted Lembert sutures. A graft was applied, time thirty-five minutes. The dog died five days afterwards. The autopsy showed death due to obstruction. The invagination had been done the wrong way, or rather toward the stomach. The proximal bowel was greatly distended with gas, and all liquid fæces. It was blue, congested, and its walls were quite thin. The distal bowel was pale and contracted. No invagination sutures were used, but in their stead circular suturing with Lembert's stitch.

The direction of the gut must be determined to have success.

*Experiment No. 149.*—Bitch; weight, 25 lbs. Animal chloroformed, and loop of intestine drawn out and divided. The proximal end had a short rubber tube stitched in with one stitch. The distal

end was invaginated three-fourths of an inch, and the proximal bowel end was inserted into it. The invagination was then retained in position by ten Lembert sutures applied circularly around the gut. Graft placed on parts.

Dog died in forty hours. The vagination continued until it passed just beyond the end of the rubber tube, and obstruction resulted—no invagination sutures were used. The dog died because the rubber tube was not long enough. This demonstrates the value of the rubber tube. The fæces may not go through the tube, but they may go along its side, which occasionally occurred.

*Experiment No. 155.*—Dog; weight, 10 lbs. Loop of intestine drawn out and direction determined by the cœcum. It was severed completely. The distal bowel end was invaginated three-quarters of an inch. A rubber tube (one-third of an inch in diameter and four inches long) was stitched in proximal end. The proximal end was inserted into the distal, and held in position by circular suturing with Lembert's stitch. A graft was applied and sutured in place. Dog died in forty hours from gangrene, caused by the pressure of the rubber tube. He was a very small boweled dog, and it was quite difficult to do the operation at all upon such a contracted gut. However, I am recording many of these operations to show how these very mistakes may be avoided.

*Experiment No. 152.*—Dog; weight, 15 lbs. The

gut was drawn out of the abdomen as usual, its direction located by the cœcum. It was completely severed. A rubber tube was stitched into the proximal gut end. The mesentery was torn off each bowel end about an inch. The distal end was invaginated three-quarters of an inch and the proximal end inserted into it three-quarters of an inch; the gut held in position by 12 interrupted sutures. A graft was well applied and sutured in position. The dog was quite well three days after, and made a good recovery; eating, drinking and playing. Twenty days after the dog was shot to secure specimen. The operation had healed nicely. The graft was firm and strong, and all organs looked healthy. The gut lumen was narrowed a little more than one-half its original lumen. Fæcal circulation seemed normal. A little enterolith was lodged above the operation, but dogs are so liable to enteroliths of straw and hay, that not much notice need be taken of such matters when dogs are kept in places where hay and straw is used for bedding. Some of the sutures were left, but most had fallen into the bowel lumen in twenty days.

Remarks: The manuscript being called to press, I have no more time at present to cultivate this operation. More work on this operation was done but not here recorded. The results were about the same. At the last we learned much more how to get better results, and will note some salient features. If the

gut is narrow, as it is in a dog of 12 to 15 pounds, the operation will give poor results. With a large gut it appears to the author that it ought to produce the best kind of results with a rubber tube. The distal end should not be invaginated more than ½ to ¾ of an inch, as it may gangrene at the neck. The mesentery should be torn off the distal and proximal gut ends about ½ inch. The circular suturing should be done with interrupted Lembert sutures. The rubber tube should fairly well fill the gut lumen and should project 3 inches above the operation, so that progressive invagination will not cause the operated parts to slip beyond the end of the tube. I got the best results from a tube no less than 6 inches long. The interrupted circular sutures must be inserted with much caution near or into the neck of the invaginated distal bowel, as gangrene occurs so easily there and fæcal fistula will arise. The graft is the very essential factor in this as in many other intestinal operations; in this case doing double duty. First, it protects the peritoneal cavity from fæcal invasion through any fistula that mightr aise, and second, it prevents progressive invagination by forming firm adhesions, and so thickening the bowel cylinder that invagination is rendered more difficult.

I wish, however, to note that all through Jobert's the author's and the author's modified Jobert operation, I had a poor mongrel set of small dogs, and a small dog has such a small gut that mortality

is naturally high. Jobert's operation with invagination sutures, and the author's modification of Jobert's without invagination suture generally narrows a dog's intestinal lumen one-third from its original size, while the author's operation only narrowed the bowel lumen about a sixth or seventh of its original lumen. It may be remembered that a dog's gut wall, is, in general, thicker than man's. This operation requires more cultivating, as it is remarkable how one can lessen the mortality of intestinal operations by careful experiment, and by diligent study in the autopsy as to the real cause of death. In every autopsy, one can eliminate its error in the next operation. The errors soon sink to a minimum.

NOTE.—After the experiments, making up this chapter, were all done, and the chapter written, I came across an article announcing that Prof. Madelung, the successor of the late celebrated Prof. Volkmann, at Halle, had done Jobert's operation without invagination sutures, but Dr. Madelung had not used the rubber tube, which is one of the essentials of the successful part of the operation. I was not aware in 1889, when I began to do this operation, that any surgeon had done the operation without invagination sutures. The idea came originally to me from dog autopsies—a suggestive school when properly respected.

# CHAPTER XX.

## RECTAL INSUFFLATION OF AIR OR HYDROGEN GAS.

To use air or hydrogen one needs a rubber balloon with a capacity of four gallons. It should be connected to a rubber tube four feet long on the end of which a rectal tube with a stop cock is fixed. It is well to have the hole in the tube made so that when it is introduced into the rectum its contact against the contained fæces will not obstruct the passage of the air or gas from the balloon.

*Experiment No. 104.*— Dog; killed and abdominal walls removed so as to observe the process. Air forced into rectum from rubber balloon. The colon quickly filled and when considerable distention existed the band of Bauhin yielded and the air rapidly traversed the small intestine to pyloris. The air in passing the ileo-cæcal valve produces a distinctly audible sound to the stethoscope and often to the ear. During the passage of air along the canal, the intestines unkink, untwist and put the mesentery on a stretch at every point. No injury or laceration was found in the alimentary canal when the air was forced through the dogs mouth. The kind of movements caused by air in the bowel would aid in breaking up adhesions and reducing invaginations.

*Experiment No. 100.*—Female cadaver; abdom-

inal wall was cut away and hydrogen from a 4-gallon rubber balloon was forced into the rectum. The operator forced the gas into the rectum by pressing the baloon between his hands and the table. The force must be steady, and persistent.

The method of entrance I directly observed in quite a number of dogs and human cadavers, and this one description will be typical of all. In no case were there found injuries or laceration. In these bodies the whole colon and cæcum were exposed and well in view. The gas first begins to fill the sigmoid flexure which describes numerous turns and twists on its axis. It straightened out all the kinks in the sigmoid and put all its mesentery on the stretch. The rest of the colon was rapidly filled and distended up to the valve of Bauhin.

Further progress of the hydrogen gas was now distinctly arrested, until the ileo-cæcal valve was rendered incompetent by the mechanical separation of its edges, when the gas passed into the ilium with an audible rushing noise. The small intestines were rapidly distended, unkinked, straightened, and the mesentery put on a stretch. In this action slight adhesions would be broken up. While lacerations of the peritoneum conveying the bowel wall were so frequent, from forcing water through the ileo-cœcal valve, in no case were lacerations found after gas or air had been forced through the valve; another proof that forcing of air or gas through the ileo-

cœcal valve does no damage, arises from the fact that often in shooting dogs, we have forced air beyond the valve to locate the perforation, and in no case did we observe injurious effects. Much water forced through the valve in animals makes them quite sick for a few days to a week, when death, from peritonitis, or recovery takes places.

When the hydrogen filled the alimentary canal, small punctures allowed the gas to escape under pressure applied to the balloon. The hydrogen would burn with a blue flame, and popping explosions, depending on the kind of pressure applied to the balloon.

The conclusion, from a reasonable number of experiments is, that the forcing of air or hydrogen gas from the rectum through the ileo-cœcal valve is a perfectedly safe and justifiable procedure. It is an operation of exceedingly great diagnostic valve, and when properly done, devoid of danger.

*Experiment No. 109.*—Dog; weight, 65 lbs. Animal chloroformed and shot while lying on back. The balloon containing hydrogen was employed by inserting the rectal tube, and an assistant grasping the rectum in such a manner as to prevent the hydrogen from returning. The balloon was placed on a table, and probably 40 pounds was slowly and gradually applied to it. The abdominal cavity gradually distended and became tympanitic, showing with almost a certainty that the intestines were perforated.

The bullet-hole in this case did not permit the hydrogen to escape; so a sharp-pointed glass tube was introduced into the bullet-hole, and the gas escaped. When a lighted match was applied, the hydrogen burned with a steady flame. Probably more pressure on the balloon would have forced the gas through the bullet wound. On opening the dog's abdomen, ten intestinal perforations were found.

*Experiment No. 97.*—Dog; weight, 90 lbs. Animal chloroformed, and shot while lying on back. Hydrogen was forced from the balloon into the rectum slowly, with probably 60 pounds pressure applied to it. The dog's abdomen began to swell, and became tense and loudly tympanitic, showing perforation of bowel. The hydrogen escaped at the wound, and when a lighted taper was applied it burned, but not very steadily, owing to the difficulty of escape through the bullet hole. I pushed a pointed glass tube into the wound, and then the freely escaping hydrogen burned with a steady blue flame. On opening the dog's abdomen, intestinal perforations were discovered.

*Experiment No. 115.*—Male cadaver; the abdominal walls were removed so that the whole process was visible. The hydrogen was forced into the rectum by pressing on the rubber balloon. It gradually distended the sigmoid, then the remainder of the colon and became distinctly arrested at the ileo-cœcal valve. Finally it distended the ilium by rushing through the valve with a considerable sound.

Fine punctures were then made in the bowel and the gas escaped. A lighted taper applied to the escaping gas made it burn with a steady flame. The punctures were gradually enlarged to observe how the gas would act. Finally a hole in the bowel was made which was just large enough to admit the thumb. The gas was then forced into the bowel and the escaping gas lighted, when quite an explosion occurred. The explosion damaged the bowel tissue to some degree. The main damage was at the seat of the perforation in the bowel.

*Experiment No. 116.*—Dog; animal narcotized and shot through the abdomen. The hydrogen was forced through the rectum from the rubber balloon. After the abdomen had distended to some degree the gas began to escape from the bullet hole. A lighted taper being applied the gas burned with a steady flame. Abdominal section disclosed intestinal perforation.

*Experiment No. 117.*—Dog, shot while on back. The hydrogen being forced through the rectum, distended the abdomen and finally escaped at bullet wound, as was demonstrated by a steady flame from a lighted taper. Laparotomy was made and perforations found.

*Remarks.*—The use of hydrogen gas, as a diagnostic test for penetrating wounds of the alimentary tract, is in its infancy. It consists in forcing gas through the rectum by means of a rubber balloon

containing the hydrogen, which can be generated by adding a few zinc chips to a dilute solution of sulphuric acid contained in a Wölf's bottle. The balloon (of four gallons) is attached to a rectal tube by three feet of rubber tubing. The balloon must be steadily compressed without interruption with from 30 to 60 pounds of pressure. It is better to have a manometer attached to measure the exact pressure which should be applied. Failures will occur at first from fæces in the rectum. The tube will become obstructed, but a little practice will overcome the main difficulties. I failed several times from not keeping up steady, continuous pressure a sufficient length of time. The objections raised against hydrogen gas are: (*a*) That recent experiments and clinical use tends to show that it is not infallible as a test. (*b*) It may act as an infecting agent. (*c*) It may so distend the bowels that their return is very difficult. (*d*) The gas, of course, will not point to any wound outside of the intestine, as the viscera. (*e*) The distension caused by the gas in the abdominal cavity endangers respiration and circulation by pressure. (*f*) Explosions might occur in using it. (*g*) Bowel contents may extravasate into the peritoneal cavity by being forced through the intestinal perforation. (*h*) The burning of the gas, if in the abdominal cavity, might destroy the peritoneum at the seat of the flame.

Most of this array of objections disappear with the practical use of the gas in experiments. It is

scarcely reasonable to expect anyone to apply the gas with a perfectly successful result during the first few trials. I think under proper care no explosion will occur. I made many trials to ascertain whether the gut at the seat of the flame would be injured by the heat. A flame of short duration will not destroy the integrity of the tissue at its seat, but if allowed to continue, an ample number of experiments showed a considerable amount of blackening and real destruction of tissue beyond producing aseptic conditions. The over and persistent distention of the bowels with consequent difficulty of reduction, is a real objection. It can be overcome by incising the gut on the convex surface, and inserting a long rubber tube which will enable the operator to conduct the gas around kinks and flexions in the gut. I have not yet seen the use of hydrogen gas enhance extravasation into the peritoneal cavity. Its infecting properties, owing to having traversed a septic alimentary canal, are small, indeed; too small to weigh in the presence of imminent danger. I think that the charge of endangering life by interfering with respiration and circulation through distension pressure is exaggerated by the theorist. I have not yet been able to observe, in using the gas, that the objection was worth entertaining. I do not think it is exactly "infallible," as it is used by fallible men in fallible conditions, who are in most cases unpracticed in its use. Any surgeon must be convinced of the great value of hydrogen gas in demonstrating

a perforation of the alimentary tract before laparotomy. It satisfies the surgeon, and appeals to the sight and sense of stubborn doctors and superstitiously ignorant laity who stand by as witnesses against any proper operation. By its very demonstrations, it will explode the "do-nothing" plan of expectant treatment, and save many a life by prompt surgery, which would otherwise be sacrified by the so-called "conservative" methods of watching life pass out like sand through an hour-glass. If it is suspected that the stomach is perforated, it can be inflated by a stomach tube. However, it may be noted that it is much more difficult to force gas from mouth to rectum than it is to force gas from rectum to mouth. It is quite difficult to force the gas beyond the stomach by way of the mouth. It was not very difficult to force gas from the rectum to mouth in my experiments.

In forcing water from mouth to rectum I have had difficulties which occasionally caused the stomach to rupture. I have not seen, so far, any injury to tissue from the presence or pressure of hydrogen gas. It may also be stated that in those cadavers in which the ileo-cæcal valve was impermeable to water, from the rectum, was easily permeable by air or gas from rectum.

The hydrogen gas is prepared by taking a wide mouthed bottle and putting a cork in it with two holes. In one hole insert a straight glass tube

through which the sulphuric acid is to be poured. In the other introduce a bent glass tube which is attached to the balloon to conduct the hydrogen from the bottle to the rubber bag, which is most convenient when it has a capacity of four gallons. Now pour in the bottle a half pint of water and throw in a few zinc chips. Then slowly pour through the straight glass tube a few teaspoonsful of sulphuric acid. When the hydrogen, has well started to generate and all the air is driven out of the bottle, attach the rubber tube of the balloon to the bent tube in the cork of the bottle. The hydrogen should generate fast enough to fill the four-gallon balloon in ten minutes. When the balloon is full attach to the end of the rubber tube a good rectal tube and it is ready for use.

The following paragraph from a paper read at the International Congress, held in Berlin, by Prof. Senn, in August, 1890, will explain itself, and show the firm belief of this surgeon in the diagnostic value of hydrogen gas to determine the existence of an alimentary perforation in gunshot wounds of the abdomen. He says, "I have up to the present time, applied this test in over 100 cases of gunshot wounds of the abdomen produced intentionally in dogs, and in every instance where the intestine or stomach was wounded, the visceral complication was positively diagnosed before the abdomen was opened."

The above paragraph impresses the author more

and more with the idea that the value of hydrogen gas as a diagnostic test, depends largely on the method of its use. I can well remember when beginning its use how we made repeated and dismal failures from lack of experimental skill. Repetition perfected its use.

It is unfortunate that so many otherwise skillful surgeons attempt to decide the highest form of diagnosis by one or even a few beginning tests of hydrogen gas. And when it proves in their hands a failure it is unsparingly condemned. One surgeon condemned it because the rectal tube was so often obstructed with fæces, as to prevent the escape of the gas. Repeated experimental trials alone will make it of real diagnostic value in any surgeon's hands.

# CHAPTER XXI.

## GUNSHOT WOUNDS OF THE INTESTINES.

*History.*—Egypt was the first home of intestinal surgery. Records inform us that the intestinal suture was used there. Authors on surgical works existed in Egypt according to the combined average, dates of Brugsch, Lepsius, Bunsen, and Mariette, over 3,600 years ago. The custom of embalming, among this people, enabled them to progress from the opportunities of seeing and examining the intestines when the bodies were opened to remove the abdominal viscera, during the stage of preparation.

Much medical knowledge was undoubtedly lost in the process of evisceration, for the reason that it was mainly the office of a class of people, ignorant and shunned for their so-called unsacred and unclean work. Twenty-three and a half centuries ago, when Herodotus was living in Egypt, he found medicine divided into specialities, and some of the specialists practiced on the intestines only. He said the Egyptians opened the dead bodies to learn of what disease the person died (good pathology). It is easily seen that the Egyptians studied the intestines for many centuries closely; and that the physicians could examine and dissect the abdominal viscera as much as they desired. I find in looking over the Bible, that Jacob died some 3,600 years ago, and "*the physicians*

*embalmed Israel*" (Jacob). The doctors were then undertakers.

In this gifted valley of the silent Sphinx, arose the celebrated anatomists, Herophilus and Erasistratus, who dissected the human body, and performed experimental operations on criminals given to them by Ptolemy. Erasistratus, we are informed, was the most celebrated abdominal surgeon of his day, boldly opening the belly to perform operations on the liver and extirpating the spleen, over 2000 years ago. The Alexandrian School of Medicine existed from about 350 B. C. to 640 A. D., thus having a consecutive existence of 1000 years, with the privilege of human dissection, and opportunity to witness general embalming, allowed unlimited fields for the progress of intestinal surgery, which no doubt under such conditions, attained a high standard. The school furnished teachers for other countries. Previous nations left no known records of intestinal surgery. The Greeks did some work with the alimentary canal, as we observe from the writings of Hippocrates. However, it was mainly rectal injections of air and fluid. They undoubtedly sutured an intestinal wound which appeared in sight. Celsus informs us that the Romans used the intestinal suture to close wounds in the bowel. It no doubt came to them from Egypt. The advent of Christ, and the erroneous application of some of his teachings, was a temporary death-blow to intestinal surgery, as it relegated

disease to be cured by faith, prayers, charms, incantations, and mystical superstition. From this date until the twelfth century, intestinal surgery is almost a blank; one can scarcely discover a landmark to note its progress. Centuries came and went with hardly a record of improvement. In the twelfth century, medicine and religion began to be divorced, which very much increased the power of both for the good of mankind. Since the twelfth century I have examined the literature of intestinal surgery. It embraces the names of about one hundred and eighty physicians who have played a more or less prominent rôle in the development of this branch. I am sorry that space forbids a mention even of the works, much less the names, of this brilliant galaxy of noble surgeons. Space permits only the notice of a few names, whose efforts have created epochs, eras, and revolutions in the advancement of intestinal surgery. Man is an animal of slow progress; and much progress is forced upon him from accidental circumstances. Intestinal surgery is mainly built on the records and labors of surgeons during the various wars. Fire-arms forced men to study intestinal surgery. The late Civil war and the Franco-Prussian, whose slaughter was unprecedented, did more than all previous wars to develop scientific knowledge and standard rules in the surgery of the digestive tube. The first great work of merit, which became such an invaluable storehouse to surgeons, was that of Dr. Travers of London,

and was published in 1812 under the title of, "*An Inquiry into the Process of Nature in Repairing Injuries of the Intestines; Illustrating the Treatment of Penetrating Wounds and Strangulated Hernia..*" It is an experimental production, able and philosophical, enriched by keen tact, excellent judgment, and original observation. Dr. Travers was a prolific genius, and intestinal surgeons are lonesome without him. It was Dr. Travers who demonstrated that a string could be tied tightly around the gut and the fæcal circulation would restore itself by the string cutting through the gut wall, while the healing of the tube followed the destruction by the string. Dr. Thomas Smith did some valuable experimental work about this time. John Bell was now rising into the great luminary of the profession, but taught the most pernicious doctrines regarding intestinal surgery that ever emanated from an otherwise great man and celebrated anatomist. Bell's theory was that there was no real *cavity* in the peritoneum, and that extravasation from an intestinal wound would not occur, because the other viscera would close and plug it up. I understand Bell was too conscientious to experiment on animals. Sir Astley Cooper abetted Bell's errors. For further growth we now turn to the French, whose brilliant achievements were laying immovable foundations and producing indelible impressions for future ages of intestinal surgery. About 1825 France might well be vainly proud of her illustrious surgeons,

for along our path we are yet glad to see the gleam of light which scintillated from their genius. Dupuytren and Baron Larey are yet great lights to study. The immortal Lembert proposed his stitch in 1825 (died in 1850). The ingenious Jobert gave to the world his celebrated invagination operation in 1822. It is a substitute for circular enterorrhaphy. Jobert also claimed priority in using the stitch named after Lembert. Baudens was an able genius and an original thinker, and took the most philosophically advanced grounds of any intestinal surgeon of his age; he undoubtedly did the first successful case of enterorrhapy for gunshot wounds on record, on a soldier in 1831; he drew the wounded colon out of the wound and sutured it, with recovery. Baudens did the first recorded laporotomy for gunshot wound in 1836, when he resected eight inches of bowel; the man died in three days from an over looked perforation in the cœcum. He united the resected bowel ends by Lembert sutures, and the autopsy showed healing. Baudens said he believed, only for this mistake, the soldier might have been saved. The bold and philosophical stand assumed by Baudens may be gleaned by the following quoted from his book published in 1836:

I do not fear to place the knife in the perforation made by the projectile in the wall of the abdomen, to enlarge it, to pursue into that cavity itself

the examination of the track it has traversed, and to apply to the intestinal lesion a prompt and effective remedy—(the suture).

Heister advocated this procedure almost 100 years previous. In 1848 and 1849, Drs. Pirogoff and Nelaton did similar work, but one patient died and the other was lost sight of on the fourth day. History records that Dr. R. A. Kinloch, of Charleston, South Carolina, after Baudens, took the ground as a distinct advocate of the principle and practice of laporotomy in gunshot wounds of the abdomen. To him we must concede priority of conception and practice, at least, of the modern art. Dr. Kinloch said, in 1863, there should be an exploratory incision in gun-shot wounds of the abdomen.

He stood firm for the wisdom of the procedure and the soundness of the principles. In 1863 he operated on a soldier, who had been shot some eight months before, for the purpose of removing fæcal fistula and restoring the continuity of the tube. Dr. Kinloch opened the abdomen, performed complete circular enterorrhaphy with silver wire used in Lembert fashion, and the soldier recovered with a slight fæcal fistula due to the failure of sutures. In 1881 Dr. Kinloch still held firm his belief of the wisdom of laparotomy for gunshot wounds of the abdomen. Eighteen years after the last and first case, a second opportunity arose for Dr. Kinloch to put in practice his principle. A negro was shot in the abdomen

with a ball of .32 calibre. Dr. Kinloch opened the abdomen, found three perforations of the tube, and closed them with Lembert's stitch; the incision was median, as it should be. The patient died in ten hours, and the autopsy showed that a wound of the small intestine, and also one of the rectum, had been overlooked. Dr. Kinloch must be remembered as the brave pioneer who cleared the land of its obstacles so that fruitful crops would follow.

In 1887 was reported that Dr. Sevastopoulo, of Constantinople, performed an exploratory abdominal incision for a gunshot wound of the intestines. He was called to the case an hour after the accident; gave no anæsthetic, but simply enlarged the wound with a pair of scissors and drew out the tube. He resected a portion of the bowel, reunited the ends with Lembert sutures, and washed out the peritoneal cavity with hot carbolic acid solution. A year after, his patient was healthy, following his profession as a wrestler. This case occurred in 1880, but was not published until 1887.

Neudörfer probably voiced the professional spirit of his day when he exclaimed in 1867: "*Was soll also der Artz mit einem durch schossenen damm machen? Gar nichts.*" (What shall a physician do with a gunshot wound in the intestine? Nothing at all.) Dr. Kocher, of Berne, had a successful case in 1883. Dr. Bull, of New York, had a successful case in 1885. Thus only six cases of laparotomy for gunshot wounds

of the abdomen are recorded up to 1885. Dr. J. S. McArdle states that up to 1887 not more than forty cases of intestinal suture for perforated wounds of the intestines were recorded, and he considered thirty-two of them genuine. Eight cases occurred in 1885 with four recoveries; 14 cases occurred in 1886 with three recoveries; seven cases occurred in 1887 with one recovery. The results of the remainder I am unable to report.

*General Remarks.*—The median incision is nearly always the most applicable. It heals better than the lateral and suits more cases. It does not seem wise to open the abdomen in the course of the bullet, for if one does laparotomy at all, every portion of the tube should be inspected, and no incision gives such perfect access to the viscera as the median. Intestinal peristalsis will draw the perforations out of the track of the ball; and also, accumulated experience shows that the ball will deviate, hence the median in-

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A few more bright familiar names are inseparable from the growth of intestinal surgery. To mention them will be simply to arouse admiration: D. Bell, Beck, Bryant, Billroth, Ashurst, Cooper, Chisolm, Dennans, Desault, Brinton, Fagg, Erichson, Emmert, Madyl, Garengeot, Guthrie, Gunther, Gely, Gross, Moses Gunn, Lauenstein, Madelung, Haller, Hennen, Hunter, Jones, Klebs, Hamilton (?), Le-Drau, Langenbeck, Littre, La Motte, Kussmaul, Lohmeyer, Legauset, Le Gros, Clark, Hahn, Morgagni, Paré, Raybard, Rahmdor, Palfin, Schenkius, Scarpa, Smith, Sabatier, Socin, Treves, Habershon.

cision. For the use of hydrogen gas the reader is referred to chapter XX.

The proper time to operate after the infliction of the abdominal wound is a very important idea, as I think on that point hinges marked success or prompt failures.

Pathological-anatomy stands all on the risk of immediate and prompt operation after the injury. In the course of human events we always have men advocating and practicing the extremes of all conditions, we have three classes of surgeons in this subject: One class will not operate at all; another class will operate on about every case; and a third class who wish to treat expectantly until grave symptoms arise and then operate. Relative to the classes of men who say laparotomy or no laparotomy, I have no criticism. In the progress of life each man must assume his own position, but for the class who wait to see what will "turn up" to decide whether to operate or not, I think they will have the worst and most regretful mortality. I know one case in which the surgeon waited three days, and then operated with a quickly fatal result.

It appears if the operation is not done within a reasonable time after the injury, it had better not be done at all until distinct fæcal fistulæ have formed, when they can be scientifically removed by operation.

If twenty-four to forty-eight hours have passed,

and the patient is doing fairly well, he should be left alone. If he get sick after one and one-half or two days, an operation will generally kill him the quickest of all remedies. However, a perforation might be repaired and the peritoneal cavity cleansed with hot water, but each concrete case must be decided by the judgement of the attending physician, and if he be not familiar with abdominal work he should send for a man who understands the technique.

I shot nearly sixty dogs through the abdomen with a .32 calibre ball, for various experimental purposes, but only attempted to save twenty-two by operative procedures. No cases were selected, and the twenty-two cases were consecutive.

Taking the 22 dogs, we find that the number of intestinal perforations made by a 32-100 ball was 102, giving an average of 4.6 operations for each dog. The highest number was 13 and the lowest number was 0. The ball generally assumed a straight line. I repeatedly found perforations of the tube entirely out of the straight course. I attributed this to movements, and also peristalsis of the bowels. It is not presumed in this chapter to say that a ball will glance from a soft or hollow viscera, but the accumulated experience of surgeons shows that the bullet occasionally deviates. It is the common experience of mankind in war and peace, that a ball projected from a gun will not always assume and preserve a straight course any more than a base-ball hurled from a pitch-

er's hand. The curves assumed by projectiles can not be mathematically foretold. The 32-100 bullet made profound destruction and shock in most of the dogs, and nearly every one passed entirely through the dog's abdomen.

*Fæcal extravasation* is one of ihe most essential dangers in gun-shot wounds of the abdomen. The intestinal perforations were found immediately after the shooting in three conditions:

1. The wounds of slight degree were found in a high state of contraction. The constriction of the circular muscles of the tube were so active that it resembled a pale, white, bloodless cord around the gut. The bowel lumen was reduced occasionally to the size of a small quill. While this muscular contraction existed, the fæces would be driven away from both sides of the wound and extravasation of bowel contents would be prevented :

2. Wounds of the bowel of more extent showed paresis of the gut wall. Only slight contraction of the tube existed. The mucous membrane was more or less everted and as the mucous membrane is larger than the muscular coat, especially if contracted, it takes the direction of least resistance and bulges out of the perforation. It thus plugs up the hole to a more or less degree. It aids to prevent fæcal extravasation but the liquid may trickle through. The relaxation of the contraction, caused by irritation, will soon allow effusion into the peritoneal cavity:

3. Complete paralysis of the gut wall due to destruction of tissue and shock to nerves. All peristalsis was arrested. The patent, open perforation allowed extravasation from the flaccid paralyzed gut simply from the law of gravity and also from the pressure of the surrounding viscera. All fæcal contents present at the location of the wound will inevitably extravasate through the perforation of the flaccid, limpid and motionless tube. Providentially, surrounding barriers of limiting exudate would begin to arise by the time the tube recovered enough vitality to assume motion, as extravasation is not driven through a paralyzed gut but may trickle through:

4. Empty bowels is the most favorable condition, in gunshot wounds, to heal and to insure safety from extravasation:

5. Extravasation is prevented by (*a*) bulging of the mucous membrane into the gut perforation, (*b*) by surrounding coils of bowel or viscera which plug the opening, (*c*) by paralysis of peristalsis giving time for inflammatory action to limit the fæcal effusion by barriers of exudate, (*d*) by omentum closing the wound with a fold, (*e*) by contact of the perforation with the abdominal parietes, (*f*) by lymph and exudate in the wound itself, (*g*) by active muscular contraction:

6. Carefully conducted and long continued experiments seem to demonstrate that gunshot wounds of the intestines (at least in dogs with a 32-calibre

ball) will be followed by fæcal extravasation in 90 cases in 100:

7. Extravasation is more liable to occur in man than in the dog, lion, bear, ox and horse with gunshot wound, while in the above named quadrupeds a very strong distinct, fibrous lamella exists in the gut wall, making the gut strong and powerful in muscle. In man and monkey this fibrous intestinal sheath becomes small and frail:

8. As the temporary muscular contraction in man's bowel is quite limited, a resort to early operation will many times alone save the patient from death due to extravasation:

9. Extravasation can occur and life be preserved by the effusion being limited by inflammatory products. This is a frequent occurrence, and the safety, then, lies in good drainage:

11. Extravasation may produce death in a few hours by shock or infection. Some dogs died in ten hours. I saw a robust young woman die in six hours from abscess bursting from the pelvis into the peritoneal cavity.

The second most essential danger in gunshot wounds of the abdomen arises in the *mesentery*. It should be carefully studied, so as to be able to recognize the limit of its vitality. Four dogs died of gangrene due to blood supply being cut off in the mesentery. A man's judgment is of little worth unless trained by experience in such cases. Gangrene

follows the most frequently when the wound is close to the bowel on the mesenteric side. Bullet wounds, which destroy much tissue on the messenteric side of the tube, generally require resection. Small perforations in the mesentery can be left untouched, but large ones should be sutured to prevent hernia. Any wound on the mesenteric border of the bowel should be covered with omentum or peritoneum before it is closed. It should be strongly impressed on every abdominal surgeon, that one of the conditions loudly calling for laparotomy in a gunshot wound is the danger of death from hæmorrhage.—I know of two cases of gunshot wounds of the abdomen which died from hæmorrhage. Bleeding was frightfully profuse in numerous experiments, and would no doubt have caused many deaths but for timely checking. Much judgment is required not to ligate too freely. In suturing the mesentery, the stitches should be applied parallel with the blood vessels, especially must this be observed in making a reef in the mesentery in order to shorten it to prevent a repeated hernia or volvulus.

According to my experiments, intra-abdominal injury occurs in 90 per cent. of cases shot through the abdomen. I shot quite a number of dogs not included in this list, but it was for other purposes, and did not attempt to save them by operation. In the present list not so many visceral injuries occurred on account of the method of shooting, but after all they were numerous.

*Wounds of the liver* were simple abrasions or distinct penetration of the organ with destruction of tissue. The Paquelin cautery is the best remedy for checking bleeding from abraded wounds of the liver; if it does not succeed the wound may be tamponed with strips of gauze, and if the abdomen must be closed, the gauze can be drawn out and held in the abdominal wound, and removed at will.

A large ragged laceration had better be trimmed and well sutured together, and a bleeding perforation could best be tamponed with iodoform gauze. I have observed long perforations through thick parts of the liver bleed about two tablespoonsful and then cease in a few hours.

Wounds of the gall-bladder are quite apt to occur, and should be closed by a Czerney-Lembert suture.

Tait, Billroth, Czerny, Holm Rydygier and a few other pioneer surgical leaders are vastly extending hepatic operations. It seems to me that the evil effect of bile on the peritoneum has been exaggerated. Dr. Senn's original work on the pancreas has thrown much light in this dark region. The pancreas was many times wounded but the organ seems to bear considerable destruction of tissue especially if it be on the edge or toward its tail. Wounds of considerable size occurring in the pancreas are compatible with life. Wounds of the spleen bleed profusely, and if the Pacquelin does not check hæmorrhage it should

be extirpated. Dogs do well after spleen extirpations. The urinary bladder was perforated and wounded, but a Czerny-Lembert suture is followed by good healing. I found that the application of a peritoneal graft on a scarified wound of the bladder was an excellent fortification. The cicatrix would heal with a graft one, two, and even three times the original thickness of the bladder wall. No kidney wound occurred, but if it did trimming, suturing or the Paquelin cautery, or extirpation could be resorted to. A severed ureter could be sutured into the colon, allowing the urine to trickle through with the fæces.

The suture almost universally applicable in intestinal work is the Czerny-Lembert. The Czerny stitch can be either continuous or interrupted. It is a stitch which can penetrates the whole bowel—muscular, and mucous coats—and unites the cut edges of the gut. The Lembert stitch is one which penetrates the serous and muscular coats, and returns without penetrating the mucous coats. It can be continuous or interrupted. The combination of the two is termed the Czerny-Lembert suture. History records some forty other kinds of sutures.

What becomes of the suture? The sutures are mostly passed into the bowel lumen. Some are encysted, and finally absorbed. Much discussion has been indulged in as to the method of absorption, some claiming, that though the stitch may be absorbed, it is done by gradually replacing its fibres with cicatri-

cial tissue, having the same form or outline as the original stitch. It would be called the same process as the so-called "petrified" wood, where a magnesium or calcium salt displaces wood fibre and assumes the same form as the original piece of wood. I have seen most of the stitches go into the alimentary canal, and have carefully observed stitches in the bowels for two months, and have simply seen cicatricial outlines left. Occasionally no trace was left, and at times the unaltered stitch remained for fifty days. I have found unaltered stitches, so far as could be seen, after forty days, inside of the canal. Weeks after the operation, I found threads hanging in the tube, and this was nearly always so following a continuous suture after circular enterorrhapy. Often sutures do no harm for long periods. I removed a pure, unaltered suture of silk, so far as was visible, one year after I had performed a cervical operation on a woman. It was frequent for me to see several sutures hanging in an artificial bi-mucous fistula a month after the operation, and even fifty days resisting the alimentary secretions.

The methods used in treating the wounds were the following :

1. A Czerny-Lembert suture closed a perforation. Generally the Czerny and the Lembert were continuous, but of course separate sutures. Grafts were nearly always applied :

2. A single or double perforation was closed by

enlarging them with the scissors, and then inserting a segmented rubber plate, and bending the plate on itself, after Dr. Brokaw's rubber ring plan. I frequently used a Czerny suture before tying the bent plate. Grafts were generally applied, and sutured in position:

3. Two perforations, if not too far apart and thus exclude too much bowel, were simply anastomosed with segmented rubber plates. This proved to be an invaluable method. I trimmed no edges of wounds. Grafts generally applied:

4. In severe mesenteric, and some other wounds, resection was performed, and the divided ends of the bowel united by (*a*) circular enterorraphy; (*b*) Jobert's invagination method; (*c*) the two severed ends were closed by invagination and sutured, and lateral anastomosis practiced; (*d*) the distal end of the gut had its mucous membrane denuded for one-half inch, and then the serous scarified proximal end invaginated into it and sutured in position. This is an operation I have introduced to avoid the invagination sutures of Jobert. In this class of cases I have not practiced circular enterorraphy with rings in the divided bowel-ends, as recommended by Drs. Matas and Brokaw:

5. Small abrasions were frequently left untouched, and the majority of cases did well.

Experiments so far demonstrate that lateral anastomosis with (segmented rubber) plates is the safest operation with a completely divided intestine. I

would like to impress on men, who do not have time to test cases by many experiments, that the whole canal should be thoroughly searched for perforations. This is said in contradiction to writers of some authority. A good plan is to pass the tube through the fingers and before the eye, returning it as fast as it is drawn out and examined. A piece of iodoform gauze or an assistant's finger and thumb should make the starting. The cœcum, sigmoid, and duodenum serve as great landmarks. The fæcal contents and also the field of operation is easily controlled by tying a rubber band around the gut on each side of the wound after the fæces have been squeezed out of the parts. The rubber band should be thrust through the mesentery with a blunt forceps. It must never be forgotten that the great obstacle to progressive, successful intestinal operations is persistent and profound shock; hence manipulations and exposure of intestines should be as slight as possible and time as short as is consistent with skilled work.

Eventration should be practiced if necessary. Shock is counteracted the quickest and safest by pouring hot water (100° to 108°) into the abdominal cavity.

General advice is given not to probe the bullet wound. I would say in the face of tradition and high authority, give the bullet wound a judicious probing. As a sample of this position I will assume the liberty of quoting Dr. L. A. Stimson from a personal communication to me on this subject.

In the second case I found the bullet in the parietes (abdominal) 4 inches from the point of entrance, a beautiful example of the value of exploration of the track.

This simple probing excluded laparotomy in Dr. Stimson's case and will exclude more in the future. An aseptic probe, blunt, judiciously used, can follow a bullet hole without harm. It of course states nothing of the great question of hæmorrhage.

The symptoms and diagnosis of gunshot wounds of the intestines are very uncertain. Profound destruction of the tube will often be accompanied by slight manifestations (probably due, in some degree, to paralysis of its walls), while insignificant injuries may show tumultuous symptoms of the dreaded tripod—*pain, vomiting, and tympanites.* Persistent nausea is a bad symptom. The escape of visceral contents, bile, fæcal matter or odor or urine, is a distinct symptom. Insufflation of gas or laparatomy announces the decision. Can rules be formed to determine whether laparotomy should be practised in gunshot wounds of the abdomen? The purpose of laparotomy is two-fold: (*a*) To repair visceral wounds: (*b*) To arrest hæmorrhage. Statistics distinctly favor laparotomy in these wounds with skilled hands, and no other should do it. I should say that each surgeon should form his own decision and judgment in each concrete case. In the present state of our knowledge of the subject, no hard or fast rules can be laid down

as to whether laparotomy should be performed or not, but "as for me and my house" we will be on the side of laparotomy for ever.

The symptoms which develop in those cases which do not progress to prompt recovery, are peculiar and distinct. Two definite forms of peritonitis arise: One is the diffuse septic peritonitis, or better, intestino-peritoneal septicæmia, as it is termed by Dr. Vechére: The other is described as the progressive fibro-purulent peritonitis, especially by Dr. Miculicz, and also noticed by Dr. Wylie. I have seen both of these forms many a time during three years, covering about 200 dog operations.

Intestino-peritoneal septicæmia is a form of intoxication. It is an infection of the peritoneal cavity due to the effusion of bowel contents into it. The infection, no doubt, enters the cavity through a perforation of the bowel or through the unbroken wall of the gut, and gives rise to fermentation producing ptomaines, which become absorbed and cause the terrible poisoning; the intoxication is so violent that death may occur within the first twenty-four hours. I have carefully made a large number of autopsies of this disease. The peritoneum shows no general inflammation, but distinctly local limited disease, manifestly indicating its local origin. Its fatal tract of destruction is bounded by visible lines of demarkation. The peritoneum is in localities a plush-red color, mottled, lighter and darker shades of red spots can be ob-

served. In the peritoneal cavity is found a brownish flocculent fœtid effusion. The bowels will be found here and there distended from local paralysis, due to the local peritonitis. The tissues undergo rapid decomposition. The subjects do not seem to suffer very much, probably from the overwhelming of the nerve centres with a flood of intoxications. Tympanites was present, but generally not in any marked or extensive degree, and the belly was not often very tender. The temperature varied according to the vital power of oxidation. When the subject was flooded with infection insufficient oxidation occurred and the subnormal temperature, if marked, was in a majority of cases a significant precedent of fatality. The time was so short that normal temperature might exist while the subject was yet sick, but abdominal temperature like temperature in any other disease or location, soon showed disease by rise or fall. It would occasionally rise to 106° F. Thirst is marked, and vomiting will occur. The progressive fibro-purulent peritonitis recently well described by Miculicz and well presented by Wylie is also distinctly local; I have observed this for several years. It begins locally and may end with many localities of encapsulated pus. These puddles of pus are all hemmed in by barriers of exudate, and walls of viscera.

The disease spreads gradually and exudate continually separates the healthy from the diseased peritoneum. I have repeatedly noticed the points where

this disease started, and absorption occurred. The treatment is to separately evacuate the pus puddles without opening the general peritoneal cavity.

The prognosis, in general, of gunshot wounds of the abdomen is toward fatality. The fatal elements concerned are shock, hæmorrhage, septicæmia and peritonitis.

The following cases of laparotomy for gunshot wounds of the abdomen, came too late to be classed with the large table, as the book had gone to press.

The first six cases were kindly sent me by Dr. J. B. Murphy of Chicago. Case 1. Bullet entered one-half inch below navel. Laparotomy revealed eleven holes in the intestines. A continuous catgut Czerny suture was used, as was also a continuous Lambert suture. The patient died of hæmorrhage on the second day, caused by an opening in the left renal artery. Autopsy showed that the intestinal perforations were air- and water-tight. Case 2. Bullet entered two inches to right of median line and an inch above umbilicus. Laparotomy revealed a hole in the liver, but no bowel perforation, and two pints of blood were found in the peritoneal cavity. Patient recovered. Case 3. Shot with a 38-100 calibre ball, which passed through liver and transverse colon. Continuous catgut Czerny and Lembert suture was used; abdomen cleansed with a boracic acid solution. Patient recovered. Case 4. Shot in abdomen. Laparotomy

revealed two wounds in the stomach, one in the liver, and one in the mesentery. The wounds were repaired, and the belly washed out with boracic acid solution; operation lasted 70 minutes. By some error the patient received two injections of morphine of one-third grain each. The prolonged operation, and opium poison, killed the patient. Case 5 was shot in abdomen. Operation revealed three perforations of bowel, and liver wound. The ball was 38-100 calibre. A continuous silk Czerny suture, and continuous silk Lembert, were used. The abdomen was not irrigated. Patient recovered. Case 6. Shot to left of navel one inch. Laparotomy was done nine hours after. Urine was 10 per cent. blood. Three perforations were found. Died 60 hours after. No cause of death could be discovered under the examinations of Drs. Murphy, Fenger, and Senn.

Dr. A. J. Ochsner, of Chicago, kindly sent me another case, shot in the stomach, operated on by Dr. W. D. Graham, but died of shock a few hours after. Dr. Ochsner also sent me other cases which were shot but no operation was performed. Curiously, one of the patients died of secondary hæmorrhage two weeks after injury.

This addition makes over 570 cases of gunshot wounds of the abdomen, on which laporotomy was performed, collected, and tabulated in this little volume. I am sorry that the limits of the book did not allow a distinct, concise description of each

case, but hope sufficient data and suggestions have been presented to aid the surgeon in arriving at the proper judgment on these complicated and difficult cases.

# CHAPTER XXII.

## STATISTICS OF GUNSHOT WOUNDS OF THE ABDOMEN.

The following tables have been prepared with as much accuracy as possible, and required long labor in searching records and correspondence; the surgeons whose names are attached kindly answered most promptly as to their latest cases. My own table, of 70 cases, is the result of some five years labor. I am aware that in some instances there is repetition or duplication, but I am unable to particularize any one case as such; moreover as each is reported with accuracy as to death or recovery, it will make no material difference in the final summing up of the percentage of mortality.

I have attempted to exclude all but gunshot wounds—even stab wounds are excluded—yet this could not be done, exactly, especially in war and battle reports where such wounds are classified as "penetrating." I have taken for granted that no laparotomy was performed for gunshot wounds of the abdomen in any war (except Dr. Kinloch's case in 1863).

The tendency of gunshot wounds of the abdomen is to fatality. This appalling fact, the stubborn position assumed by the laity and some influential surgeons combine to force laparotomy into the background. Dr. Frank H. Hamilton, of whom Prof. Moses Gunn remarked "no man understood the

treatment of wounds better nor would acknowledge an error quicker," said in 1865:

Be assured the patient will have a better chance for life if we let him entirely alone, and it surprises us that any good surgeon should think different.

Two years later Neudörfer voiced European sentiment when he said: "Nothing at all" should be done with a gunshot wound of the intestine. Colonel Otis states that in the American Civil War only five or six unequivocal recoveries from gunshot wounds of the small intestine were known; he also states, that of 64 gunshot wounds of the stomach, coming under surgical observation, only one single case of undoubted recovery occurred. He takes, however, a more favorable view of gunshot wounds of the large intestine and shows that in a list of 59 cases 41 make a partial or complete recovery. But structure, position, function and condition, of the large intestine may conduce to more recoveries from large gunshot wounds of the small bowel; further, the difference presented by Otis will not, I think, bear crucial analysis.

I have sought to make my statistics of value for comparison. I am in favor of laparotomy in gunshot wounds of the abdomen, but have been careful not to distort the tables to meet my own views. At present writing I have collected 11,317 cases without laparotomy showing a mortality of 80 per cent.; have collected 566 cases with laparotomy, showing a mortality of 64 per cent.; this exhibits in favor of laparotomy of 16 per cent., hence, laparotomy is a matter well worthy of consideration.

It should be remembered that the majority of laparotomies have been done by men not specially trained in intestinal surgery, which is of recent origin and course. Though a man may be skillful in other branches, abdominal surgery requires special training; hence with accumulated experience, and skill, future laparotomies for gunshot wounds should show a still less percentage of mortality.

Isolated groups and tables do not show, from environments, generalized results, but all groups and tables, combined and averaged, may be considered to represent the whole subject generally and truthfully. The presentation of statistics from New York, kindly sent me by Dr. Stimson, will clearly show the difference between a local and general table:

Gunshot wounds of the abdomen, treated in New York City, without laparotomy from 1876–1884:

| No. Cases. | Recovery. | Died. | Mortality. |
|---|---|---|---|
| 18 | 4 | 14 | 77.77 per cent. |

Gunshot wounds of the abdomen, treated with laparotomy in New York City, from 1884–1889:

| No. Cases. | Recovery. | Died. | Mortality. |
|---|---|---|---|
| 15 | 4 | 11 | 73.33 per cent. |

The foregoing gives a favor toward laparotomy of only 4.44 per cent., while a general table favors laparotomy by 16 per cent.

The tables without laparotomy are, and always will be, delusive for we can not know the extent of injury inflicted on the intestine; and it must now be accepted as definitely proved that a bullet can pene-

trate the peritoneal cavity and not perforate the alimentary canal. This is especially so with bayonet and penetrating wounds which are excluded from the present tables. When one begins to compile statistics for gunshot wounds of the abdomen, he finds great difficulty in securing records that are accurate; chaos, deficiency, indefiniteness, disjointedness and exageration, characterize many of these records.

Dr. A. Schachner, of Louisville, Ky., shot a series of 32 dogs, and attempted to save them. His statistics show a mortality of 47 per cent. I shot my dogs with a 32-100 calibre bullet, and had a mortality of 65 per cent. Much depends on the size and velocity of the projectile and also on the kind of environments, as infection is the dreaded foe in such work, enhanced by shock and hæmorrhage.

Five of Dr. Schachner's dogs, had no operation performed on, four of which died; while one with a shallow wound, produced by a 22-100 calibre ball, got better and escaped in a week. There was no autopsy to demonstrate what tissues were affected, or whether the ball entered the peritoneal cavity. We shall here note some of the main points in a paper by Prof. Senn, at the International Congress recently held in Berlin.

Dr. N. Senn experimented on cadavers to determine the frequency and number of visceral wounds of the stomach and intestines that may be expected by penetrating gunshot wounds. He suspended the cadavers in the erect posture, and then shot into the

abdomen a 22-calibre conical ball at ten feet distance; the experiments were made on cadavers from one to three days after death, and therefore some gas would exist in the intestines, expanding them. Of fourteen cadavers experimented on, the records are so different from those generally published, and from my own in shooting through the abdomen of dogs either lying on the back or standing on the feet, that it seems best to notice them still further. The cadavers were shot in an antero-posterior direction, and it seems quite remarkable that in Experiments Nos. 1, 7, 8, 9, 12, and 13, there was no stomachic or intestinal perforation; six out of fourteen had no alimentary perforation. It is also remarkable that in the whole number of perforations there were only twenty-two; the highest number in one cadaver was six. It should be observed, according to the records of these experiments on erect suspended, that six times the ball entered the peritoneal cavity without causing alimentary perforations. This is very different from my experiments, where I shot over forty dogs, and in only two did the 32-100 calibre ball enter the peritoneal cavity without making an intestinal perforation. Prof. Senn's experiments show that the ball failed to make intestinal perforations in cadavers the ratio of 42 per cent. Is there anything in the suggestion that the conditions of living and dead bodies may be different? Prof. Senn thus advocates that laparotomy is not required, because a ball has entered the

peritoneal cavity, but should be limited to the treatment of intra-abdominal lesions, which, without operative interference, would tend to destroy life. It must not be forgotten that experiments demonstrate that shooting in an anterio-posterior direction does not make by far so many alimentary perforations as shooting through the abdomen in a transverse direction. Some of my experiments revealed thirteen holes in the intestines by transverse abdominal shooting, and from anterio-posterior shooting no perforation.

Statistics of gunshot wounds of the abdomen in which laparotomy was performed. The different tables represent the various collectors:

| | No. of Cases. | Recovered. | Died. | Mortality. |
|---|---|---|---|---|
| | | | | Per cent. |
| Coley | 144 | 50 | 94 | 65.27 |
| Morton | 110 | 36 | 74 | 67.27 |
| *Author* | 70 | 35 | 35 | 50.00 |
| Dalton | 69 | 27 | 42 | 60.86 |
| Carson | 43 | 13 | 30 | 69.76 |
| Stimson | 33 | 7 | 26 | 78.78 |
| McCormac | 32 | 7 | 25 | 78.02 |
| Barker | 26 | 16 | 10 | 38.46 |
| Schachner | 12 | 0 | 12 | 100.00 |
| Barrow | 6 | 2 | 4 | 66.66 |
| Senn | 5 | 2 | 3 | 60.00 |
| Bernays | 5 | 3 | 2 | 40.00 |
| Parkes | 3 | 1 | 2 | 60.00 |
| McGraw | 2 | 1 | 1 | 50.00 |
| Matas | 5 | 1 | 4 | 80.00 |
| Warren | 1 | 0 | 1 | 100.60 |
| Total | 566 | 201 | 365 | 64.48 |

Death rate, 64 per cent.

GUNSHOT WOUNDS OF THE ABDOMEN WITHOUT LAPAROTOMY.

| | No. of Cases | Recovery. | Died. | Mortality. |
|---|---|---|---|---|
| | | | | Per cent. |
| Twenty-three European wars.. | 1146 | 285 | 861 | 75.13 |
| The U. S. civil war ..... | 3475 | 444 | 3031 | 87.22 |
| Franco-Prussian war..... | 1600 | 489 | 1111 | 69.43 |
| Dr. Stimson's New York table. | 18 | 4 | 14 | 77.77 |
| Dr. Richardson's table, New Orleans..... | 32 | 13 | 19 | 59.37 |
| Dr. Vance's table, Cleveland, O. | 16 | 11 | 5 | 31.25 |
| Matas', New Orleans..... | 72 | 33 | 39 | 54.16 |
| Total ..... | 6359 | 1279 | 5080 | 79.88 |
| Dr. W. B. Coley's ..... | 4958 | 945 | 4013 | 80.93 |
| Total summary..... | 11317 | 2224 | 9093 | 80.34 |

Death rate, 80 per cent.

Dr. W. B. Coley kindly sent me his latest statistics, and the close agreement of the tables should be observed. I knew nothing of his collection, and he knew nothing of mine, yet the difference in the two is only about 1 per cent. in mortality,—his table is 4958 cases with a mortality of 80.93 per cent. and mine 6357 cases with a mortality of 79.88 per cent. This would seem to evidence the statistics are fairly accurate. The list of cases with laparotomy have been very carefully collected from literature, personal correspondence, and knowledge of unpublished cases.

The final table will stand in the following form;

| | No. cases. | Recovered | Died. | Mortality. |
|---|---|---|---|---|
| No laparotomy. | 11317 | 2224 | 9093 | 80.34 per cent. |
| Laparotomy. | 566 | 201 | 365 | 64.48 per cent. |

There is, therefore, 16 per cent. in favor of laparotomy.

Dr. Aug. Schachner, of Louisville, Ky., kindly sent me a very significant table of gunshot wounds of the abdomen occurring in that city. The whole number was 15. Laparotomy was performed on 12; no operation in 3. All died. Of the 12 cases on which laparotomy was performed, 6 died of hæmorrhage; the 3 on which no operation was performed also died of hæmorrhage. It is very important to observe that 9 cases out of 15 died of hæmorrhage, in this table.

Practical experimental work has demonstrated to to me that hæmorrhage in gunshot wounds of the abdomen will receive more attention from surgeons in the near future.

In this table 2 died from uremia, 2 from peritonitis, 1 from shock, and 1 from delirium tremens. The longest time any patient lived was 4 days, the shortest 12 hours.

M. Réclus published some views on gunshot wounds which have excited various opinions. He mentions some 50 cases, collected by Saint Laurent and Mr. Vougnes, in which recovery followed without

laparotomy. It is said that all these positively had the pathognomatic signs of perforation such as hæmateuresis, bloody stool, fæcal matter coming from the wound, etc. The criticism of M. Réclus would arise in the much discussed point: What is *the* pathognomonic sign of perforation?—surely few surgeons would rely wholly on blood in the vomit or in the stool, since both might arise from simple injury. Fæcal matter in the wound is no doubt pathognomonic, but it is rare as a fact. M. Réclus advocates: 1. Rest: 2. Vigorous compression of the abdomen to prevent fæcal extravasation or hæmorrhage: 3. large doses of opium: 4. When these fail laparotomy is justifiable.

I positively and emphatically disagree with the 4th point, as, when other treatment has failed, so much valuable time has been lost that operation is, in the main, unjustifiable, as it then, generally, hastens death. Neither is Réclus' argument as new as it appears. Have not all the wars, fought with fire-arms, shown that only one in five of gunshot wounds of the abdomen recover?. M. Réclus, possibly, begs the question, in showing that laparotomy is not required because once, in the course of 37 cases, the bullet penetrated the peritoneal cavity but did not wound the gut.

All agree, however, that an empty gut favors healing, and that by giving dogs purgatives before shooting some may be saved without laparotomy.

M. Réclus argues man is less liable to extravasation than a dog, on account of the short gut in a dog, but does not state whether the 50 cases mentioned by him were all he observed. Hence, we do not know what his observations of mortality are. Further, his argument is weakened by not being supported by comparisons with cases which die and on which autopsy is held. I am acquainted with some surgeons of to-day who, with knowledge of peritoneal penetration with a ball, would not advocate early laparotomy. M. Réclus has presented his side of the subject brilliantly, but one can not help feeling that if we knew all he omitted to say, he would not feel so enthusiastic as his paper appears.

There is a head and front of 16 per cent. in favor of laparotomy resting on the rock of statistics that are fairly accurate; further, such agree with reason. It is quite apparent that some surgeons, able and influential, are causing a reaction in too frequent laparotomies, which will be of value in causing the operator to halt and consider when he knows the merits and demerits of operation for gunshot wounds of the abdomen must not be judged by single and isolated cases, however brilliant or fatal. I am in possession of two pamphlets by Dr. David Barrow, of Lexington, Ky., who had under his care six cases of laparotomy for gunshot wounds of the abdomen. Four died and two recovered, The causes of death were: Hæmorrhage, one; shock, one; septic perito-

nitis, one; and one died because the bile duct was cut, allowing the bile to flow into the peritoneal cavity. Dr. Barrow has written an able, sensible paper, showing the marks of a trained surgeon and an accurate observer; however, I can not agree with all of his conclusions.

I do not think such positive deductions can be drawn from the present status of surgery, but that the discretion of the individual surgeon, the position of the patient and the direction of the ball in the body, must be considered in arriving at the final decision. In my later experiments where I varied the position of the dog and also the direction of the bullet, it was found the missile could pass through the abdominal cavity and not wound the alimentary canal. At first I could scarcely believe it, but absolute experiments positively proved such was the case, and the animals recovered.

I am in favor of laparotomy, and so is 16 per cent. of statistics; but I oppose the view that every gunshot wound of the abdomen should be subject to such operation, and base this view on an experience of nearly 200 operations on the intestines of dogs. The dog is sufficiently like man to be a good standard of measurement, and my experiments often demonstrated that 40 minutes of exposure and manipulation of the abdominal viscera sufficed to induce a fatal result. The animals at times died from shock due simply to exposure and manipulation—of course

the *time* of the operation has vast influence on the result. The statistics of over 11,000 gunshot wounds of the abdomen, with no operation show, a mortality of 81 per cent.; the above paper states it at over 90 per cent.. Dr. Barrow further adds the hydrogen gas test is of use only in demonstrating the closure of all the perforations, and should be used just before closing the abdominal incision; but I regard the hydrogen test as capable, when properly employed, of informing the surgeon, in nearly all cases, whether the alimentary canal is perforated or not; and if not perforated no laparotomy is required, except, perhaps in case of hæmorrhage, which often calls for operation more loudly than intestinal perforations. Dr. Barrow gives a synopsis of Dr. Morton's table of 110 cases which is of interest. Of these, 36 recovered and 74 died, a mortality or 67 per cent.; the causes of death were: Septic peritonitis, 29: Hæmorrhage, 15: Delayed operations, 13: Shock, 9: Overlooked perforations, 3, and: From other causes, 5—I would here call attention to the fact that 20 per cent. died of hæmorrhage. The abdomen was opened 8 times and no viscus found wounded. There were 21 cases where the alimentary canal was not wounded, 11 of which recovered and 10 died. Of 5 kidney wounds all died save one, who was saved by removal of the organ. The effect of drainage is shown by its use in 21 cases in which 6 recovered and 15 died; and in 8 cases where no drainage was used, 2 recovered and 6 died

—I thoroughly agree with Dr. Barrow that drainage tube and irrigation are essential factors in visceral wounds of the abdominal cavity.

Through the kindness of the author I am in possession of two papers by Prof. T. A. McGraw, of Detroit, who makes some radical statements, and has also performed some remarkable experiments.

The first case presented was a traumatic stricture of the jejunum which was resected, removing three inches of gut. The divided bowel ends were united by a Czerny-Lembert suture. The patient recovered.

I would suggest in this case that intestinal anastomosis would have become in the highest degree applicable, and could have been done in a few minutes. All required would have been, to incise the bowel a few inches above and below the stricture, insert plates, and tie them together.

Dr. McGraw notes that he chose circular enterorraphy because it would result in the most uniform bowel lumen—no kinks, curves or narrowing. My experiments prove that more narrowing occurred from circular enterorrhaphy than from anastomosis. He also suggests fæces will accumulate in the cœcal or pouched ends of the bowel projecting beyond the artificial fistula; but in my work fæces never once collected in those points, though enteroliths of straw, hay, or hair—debris—collected several times on the proximal side of the artificial fistula, but did not kill

any of my dogs; a like condition could not accrue to man because of the nature of his food. I also object to performing circular enterorrhaphy with the continuous Lembert suture; it should be interrupted several times in the circumference of the gut. My criticism is based on experiments resulting in narrowed gut-lumen, and long threads dangling therein, subsequent to the operation for an indefinite length of time, threatening fæcal fistula.

The next case of Dr. McGraw's was resection of eight inches of the colon followed by circular enterorrhaphy with a Czerney-Lembert stitch; the patient died on the fifth day from fæcal fistula due to yielding of the sutures. Here I think anastomosis would have been preferable, because the anastomosed parts would not have given way so easily, and local inflammation accompanied by a local catarrh would likely have liquefied the fæces and allowed free circulation; I also think the safety of any intestinal operation is enhanced by an omental graft, which Dr. McGraw did not apply.

The second paper of Dr. McGraw's is most far reaching and replete with keen observation and remarkable experiments.

The first proposition made in this essay is, that incomplete operations are probably the safest in many cases; *e. g.*, when a subject is shot, Nature begins to surround the wounds with lymph barriers and to encapsulate the infective material.

The idea of Dr. McGraw is to simply cut down into those cavities, irrigate, and drain, and not to break up the newly formed cavities as that would infect the whole peritoneal cavity. This is only an application of Miculicz's and Wylie's treatment of progressive fibro-purulent peritonitis, and by such partial operations shock and accompanying dangers are lessened.

I cannot wholly agree with this manner of operating, since I believe if an operation is done it should be in the median line and the whole canal inspected if required. He speaks in very emphatic terms against evisceration, as he terms it; and I am fully aware of the profound shock in eventration and advocate it only under extreme necessity. The shock, however, is generally more from dragging on the great plexus and ganglia of the sympathetic than from exposure, and I therefore practiced another method which inculcated far less shock, viz., to pass the gut through the finger and before the eye, returning as fast as it is drawn out; the gut should be grappled by the finger and thumb as seldom as possible. Hæmorrhage often demands eventration. Dr. McGraw's expectation of Nature encapsulating gunshot wounds by lymph and other means is rather higher than most surgeons'.

Dr. McGraw shot 4 dogs through the abdomen with a 22-calibre ball; all recovered; were killed on the 12th day. In No. 1 no trace of ball could be

found inside or outside. In No. 2, it had penetrated the spleen and cut four holes in the small bowel and one in the large bowel. All the five bowel perforations had healed by agglutination and adhesions. In No. 3, the spleen was perforated and several holes made in the small intestine; the wounds were healed, except two, which were plugged by adhesion to adjoining coils. In No. 4, there was only a wounded spleen.

I might remark here, that very much depends on the size of the ball, as in dogs shot with a 32-100 ball, in my experience, were profoundly affected and died speedily if not operated on.

Five sheep were experimented with by Dr. McGraw in a similar manner: No. 1 had a stomach and three small intestinal perforations; the animal died of hæmorrhage, and had fæcal discharge in the abdominal cavity from each of the perforations: No. 2 had a stomach and a small bowel perforation, but no extravasation: No. 3 had only the vena cava perforated, which of course caused death: No. 4 died from hæmorrhage. The spleen was perforated, and extravasation occurred from wounds of stomach, and large and small bowels: No. 5 had slight extravasation from stomach, and large and small bowel.

It was thought that two out of five could have recovered from their wounds, hence the Doctor argues that wounds from a 22-100 ball may often be recovered from without operation.

Sixteen bullets were fired through dead animals, and only one showed any deviation from a straight line. Most surgeons agree with this, but the accumulated experience of men in war and peace is, that balls will occasionally deviate from a straight course. A baseball pitcher can throw a ball, giving it various curves. However, whether the ball curves, or peristalsis, or gravity, or change of position cause the change of the perforations from a straight line, I can say that time after time I have found the holes in the bowel out of a straight line ten minutes after the shot was fired. We do not yet know the law of intestinal movements.

Finally, Dr. McGraw says: "An object in operating is not to make a complete and logical operation; it is not to sew up every possible wound of intestine; but is, if possible, to save our patients." Also: "It is better to have an occasional patient die of an undiscovered wound than to kill many by unnecessary procedures. * * * Laparotomy and drainage should then take the place of laparotomy and repair of intestinal wounds."

Dr. McGraw kindly sent me also two unpublished cases. The first was a policeman, aged 28, shot through the bowels by a burglar with a 38-100 ball, that entered an inch below the navel and two inches to the left of the median line. The man suffered from shock within an hour of shooting; was operated on by a median incision; nine holes were found in the

intestines. Terrible hæmorrhage occurred from perforation of the left iliac vein, which could not be reached by making a transverse incision toward the left from the median incision. The gut was resected twice, when the patient was nearly moribund, and did not rally—died the next morning. Hæmorrhage was the cause of death. The second case was a man shot through the stomach. Dr. McGraw operated within an hour of the accident. The ball had passed into the body four inches above and to the left of the navel, and continued backwards. An incision was made through the wound four inches to the left and parallel to the median line. The ball had passed through the great omentum and great curvature of the stomach, lodging somewhere in the back; gas bubbled through the stomach wound. The blood-clots were removed and wounds closed; the patient vomited black fluid from the stomach. Abdominal wound healed by first intention, but a spot of dullness developed in lower back part of left lung, which gradually extended to lower edge of scapula. At writing, the patient is convalescing, but still under observation.

This case illustrates the method of opening the abdomen by following the bullet wound, a method Dr. McGraw had previously advocated.

By courtesy of Prof. C. T. Parkes I am able to present his experience in gunshot wounds of abdomen. He has operated three times, with one recov-

ery; one died of shock three hours after operation, and one died of hæmorrhage.

Here may be noted the fatality of gunshot wounds under any circumstances, for Prof. Parkes is a trained anatomist and surgeon, and yet his mortality was two out of three. He had made a large number of original experiments in gunshot wounds, in fact some of the most instructive work up to 1885, yet in his hands 66 per cent. died. This should teach the novice to leave such work for experienced hands alone; for it is a fact that no domain of surgery is so exacting in demanding trained dexterity as that of the abdomen.

# CHAPTER XXIII.

## EXPERIMENTAL GUNSHOT WOUNDS OF THE ABDOMEN.

*Experiment No. 71.*—Bitch; weight, 10 lbs. Chloroformed, and shot while lying on side; missile, 32–100 bullet, fired three feet from the belly. Laparotomy was immediately performed in median line. The manner of eventration was, to seize a loop of small intestine, and hand it to an assistant to mark a starting point, and then pass gut through the fingers and before the eye. My many experiments demonstrated this to be the only certain method of examining viscera—one must see to know; seven holes were found in the bowels. No fæces were actually seen in the peritoneal cavity, but they showed around edges of the intestinal perforations, and would in a short time extravasate into abdominal cavity. The gut perforations were of three kinds: One simply abraded through the serous to the muscular coat, and might possibly penetrate the mucous membrane, causing the bowel to exhibit a contracted state; the circular constriction was often so active that the bowel presented, around its entire circumference, a pale, white, bloodless cord, and which presented extravasation of fæces by driving directly away from the wound; the constriction was thus caused by local peristalsis due to the irritation of the bullet, and narrowed the intestinal lumen one-

fourth, one-third, or one-half, and as high as two-thirds: Another appeared where the mucous membrane everted and aided the contracted condition of the gut to prevent extravasation of fæces by partially plugging or completely closing the perforation: The third was when the bullet struck the bowel so as to partially or totally paralyze it, allowing any fæces which existed in the vicinity to extravasate through the perforation. The intestine in such case would be in a flaccid, limp condition from shock, with patent wound, and fæcal matter lying ready to invade the peritoneum on any disturbance. These three conditions were present in this animal from the time she was shot, up to the completion of the operation—about 45 minutes.

The intestinal perforations were all closed by Lembert stitches, both continuous and interrupted. Two of the wounds were covered with severed omental grafts, while four were covered with a single, unsevered, omental flap sutured in position. Fifty-two days after operation, the dog was fat and healthy; her recovery was uninterrupted, and she began to eat on the third day.

*Experiment No. 73.*—Dog; weight, 50 lbs. Shot with 32-100 ball at short range. Laparotomy revealed eight distinct perforations, two of which tore down to mucous membrane; four of the perforations were closed with a Czerny-Lembert suture and covered with peritoneal grafts; four were found on the

mesenteric side, and were resected, the bowel ends invaginated and closed by four to six sutures. The distal and proximal gut was then anastomosed with raw-hide plates and graft applied.

He died 40 hours after from an error in tying suture at one end of the plates, as a fæcal extravasation took place, causing intestino-peritoneal septicæmia; all wounds were healing very actively. The infection went out definitely from one point, and death was due to a mistake in technique of operation.

*Experiment No. 75.*—Dog; weight, 40 lbs. Missile, a 32-100 ball, fired at short range. Laparotomy revealed three large perforations, located near the concave side of bowel, and two large holes in the mesentery, close to the bowel; hæmorrhage was profuse, requiring ligation of the mesenteric artery. Perforations closed by Czerny-Lembert suture, and an anastomosis with segmented rubber plate on the distal and proximal side excluded the wounds from the active fæcal circulation, which was done as a trial; graft applied.

He died 36 hours after from gangrene of intestine, caused by ligating the mesenteric artery; two inches were gangrenous, but wounds were healing well; anastomosis well-established.

This was a good sample of local paralysis of a bowel segment by gangrene and local peritonitis, causing accumulation of gas in intestines; much care must be exercised in ligating mesenteric arteries.

*Experiment No. 76.*—Bitch; weight, 20 lbs. After shooting, laparotomy revealed ball had only passed through the abdominal walls, and not perforated a single coil of bowel. We anastomosed the bowel with segmented rubber plates; no graft. Recovered well.

*Experiment No. 74.*—Bitch; weight, 20 lbs. Shot with 32-100 ball. Laparotomy revealed one hole, which was closed by Czerny-Lembert stitch; applied no graft. I then invaginated the bowel (small) 7 inches, sutured in position, and anastomosed above and below the invagination with rawhide plates; graft applied. She died six days later from fæcal fistula at side of plate. The invagination remained *in situ*, but a little shortened. The apex was gangrenous, and would admit the tip of the little finger. This was really a recovery, but the dog died from a fistula due to the sutures of the plates being tied too tight. The shot-wound healed all right.

*Experiment No. 78.*—Bitch. Laparotomy, after shooting, revealed two holes on the side of the intestines, about one-half inch apart. A single segmented rubber plate was introduced into bowel after gun-shot wounds were united. The six sutures on the plate had six needles passed from the lumen of the gut outward, and then the plate, being bent on itself, was tied together, leaving the two gut wounds between its parts. I received this suggestion from Dr. Brokaw, of St. Louis, Mo. The dog was scarcely sick. She ate on the second day.

*Experiment No. 79.*—Bitch; weight, 12 lbs. Shot through abdomen. Laparotomy revealed one perforation, which was closed by Czerny-Lembert stitch and a severed omental graft. She had an uninterrupted recovery.

*Experiment No. 81.*—Bitch; weight, 40 lbs. Shot. Laparotomy brought to view two perforations, which were joined by incision, and a segmented rubber plate introduced and bent on itself. The needles penetrated the gut from within out, when the corresponding sutures were tied; no graft. Very acute kinks were thus often made, but autopsies invariably showed they never caused obstruction. The animal died after 36 hours from intestino-peritoneal septicæmia, due to to fæcal fistula at the acute angle of the rubber plates. This operation has thus far not proved successful, and is merely on trial.

*Experiment No. 82.*—Dog; weight, 40 lbs. Shot through abdomen. Laparotomy revealed eleven holes in bowel and five large holes in mesentery, some of which latter bled freely, requiring ligation. I joined two of the openings with segmented rubber plate, and closed the remainder by Czerny-Lembert sutures; the mesenteric perforations were not closed. Over the rubber plate I applied a severed omental graft, but over the nine sutured perforations unsevered grafts were applied. Dog died in 40 hours from gangrene of some two inches of gut. The mesentery was torn from the concave border of the

bowel so extensively that it cut off the feeding artery, —such pieces should be resected. All wounds were healing nicely.

*Experiment No. 83.*—Bitch; weight, 40 lbs. Shot. Three perforations. Two in gut were joined, and a segmented rubber plate used; the other bowel wound closed by a Czerny-Lembert suture; grafts applied. Dog died in 48 hours from intense local peritonitis, the cause of which I could not discover though I made a very careful autopsy. It was likely infection from contact during operation.

*Experiment No. 84.*—Dog; weight, 20 lbs.; shot, making eleven perforations; four large wounds in mesentery. Single rubber plates were employed for two perforations, each being closed by bending on itself. Two more were closed by anastomosing bowel with rubber rings. Seven, by severing the intestine completely, and invaginating enough to include four holes in one and three in the other, and end closed by a few continuous sutures.—These both lay beyond the proximal and distal side of the anastomosing rings.

Dog died of shock in 15 hours, due probably to manipulation of viscera, for autopsy showed all the wounds healing nicely; every perforation and wound was sealed hermetically by a thick cementing exudate.

*Experiment No. 85.*—Dog; weight, 20 lbs.; shot at short range. Laparotomy revealed wound had almost severed gut, and bladder severely perforated.

A rubber plate closed the bowel wound, while the bladder was closed with Lembert stitch.

Dog died 60 hours after from infection received during operation. The bladder wound had healed perfectly, and the wall at that point had trebled in thickness. The omental graft applied to bladder wound was firmly adherent. The intestinal perforation also was healing nicely. It must be noticed that wounds in general heal, but infection from imperfect environments often gains the victory.

*Experiment No. 86.*—Bitch; weight, 16 lbs. Shot. Two holes made by destruction of intervening tissue; a rubber plate bent on itself closed the perforation; graft applied. Dog died 48 hours later from infection starting distinctly from bullet wound. The bowel wound was healing well.

*Experiment No. 87.*—Dog; weight, 10 lbs. Shot. Seven perforations; the gut and mesentery terribly lacerated; hæmorrhage severe. Three inches resected; the ends invaginated and closed with sutures; 18 inches of bowel were excluded by anastomosis with segmented rubber plates—each inserted into an intestinal perforation to anastomose. Four bowel ends were thus invaginated; grafts applied. He died of shock twelve hours later. Visceral wounds were all healing nicely; wound of descending colon overlooked, but would never have caused trouble as it was only abraded to the mucous membrane, and further was healing.—One must see to it that the ap-

plied graft comes in contact with the whole wound, and that it does not stretch across depressions like a drum head.

*Experiment No. 89.*—Bitch; weight, 16 lbs. Shot. Four bowel perforations, of which two were closed with Czerny-Lembert sutures, and two by anastomosing with segmented rubber plates; operation 55 minutes. Recovery uninterrupted throughout.

*Experiment No. 128.*—Dog; weight, 25 lbs. Shot. Three holes in gut; two anastomosed by rubber plate, and one closed by Czerny-Lembert suture; grafts applied. He was scarcely sick, and soon became fat.

*Experiment No. 129.*—Dog; weight, 20 lbs. Ball entered just above the navel. The gut was cut across and the ends invaginated, which disposed of four holes; the invaginated ends were secured by continuous suture. One hole was closed by a Czerny-Lembert suture; the remaining two perforations were closed by inserting segmented rubber plates, invaginating three inches from one end of bowel, one inch from other, were resected. He died 40 hours after from fæcal fistula arising at the side of the plate caused by tying a suture too tight.

*Experiment No. 130.*—Bitch; weight, 130 lbs. Ball entered abdomen just above navel; eight bowel perforations; severe hæmorrhage which was checked by applying thumb and finger to the artery and holding for a short time. The perforations were extremely large and lacerated; six of the holes were

made by twos at three points. The gut was cut across with scissors in two points, the four ends invaginated and closed by a continuous suture, excluding physiologically a piece of gut from the fæcal circulation. Now the distal and proximal ends of intestine were anastomosed by rubber plate. No grafts. Time 55 minutes. Great shock followed the extensive damage to the bowel by the bullet, and she died 48 hours later from diffuse septic peritonitis caused by the end of a gut dis-invaginating itself.—The intestino-peritoneal septicæmia was remarkably impressive and distinct in this case; its infection was fixed in location and the tract of invasion certain. Plates well in position and anastomosis nicely healing as well as all other wounds.

*Experiment No. 131.*—Dog; weight, 20 lbs. Shot. Four intestinal perforations; the mesentery was badly lacerated. The gut was twice cut across, the four ends invaginated and closed with continuous suture. The distal and proximal gut were anastomosed rubber plates, three feet of ilium thus being physiologically excluded. Grafts applied. Time, 45 minutes. He died 40 hours later from gangrene of the mesentery due to a ligated artery cutting off nourishment. The anastomosis was in this case particularly fine and healing. Almost perfect approximation and coaptation by the rubber plates with consequent hermetically sealed wounds and strong adhesions existed.

RECORD OF TWENTY-TWO CASES, SHOWING NATURE OF WOUNDS, METHOD OF TREATMENT, CAUSE AND PERCENTAGE OF MORTALITY, ETC.

| No. of Case. | No. of Perforations. | Plate used. | Death. | Recovery. | Cause of Death. | Graft | Mesentery wounded. | Resection. | Time of Operation. | No. of ends invaginated. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Inches. | Min. | |
| 132..... | 5 | | | R | ..... | " | " | 7 | 75 | |
| 131..... | 4 | Seg. rubber. | D | .. | Gangrene. | " | " | .. | 45 | |
| 130..... | 8 | " | D | .. | Disinvagination. | " | " | .. | 45 | 4 |
| 129..... | 7 | " | D | .. | Suture infection. | " | " | 4 | 55 | 4 |
| 71..... | 7 | " | .. | R | ..... | " | " | .. | 70 | |
| 87..... | 8 | " | D | .. | Shock. | " | " | 3 | 35 | 4 |
| 128..... | 3 | " | .. | R | ..... | " | " | .. | 45 | |
| 86..... | 2 | " | D | .. | Infection thro' bullet hole. | " | .... | .. | 30 | |
| 85..... | 2 | " | D | .. | Infection. | " | .... | .. | 50 | |
| 84..... | 11 | " | D | .. | Shock. | " | " | .. | 70 | 3 |
| 83..... | 13 | " | D | .. | Infection. | " | " | .. | 45 | |
| 79..... | 1 | " | .. | R | ..... | " | .... | .. | 30 | |
| 82..... | 11 | " | D | .. | Gangrene. | " | " | .. | 50 | |
| 81..... | 2 | " | D | .. | Perforation at plate. | " | " | .. | 40 | |
| 78..... | 2 | " | .. | R | ..... | .. | .... | .. | 25 | |
| 74..... | 1 | " | .. | R | ..... | " | .... | .. | 50 | |
| 76..... | 0 | Ileo-ileostomy | .. | R | ..... | .. | .... | .. | 25 | |
| 75..... | 3 | " | D | .. | Gangrene. | " | " | .. | 45 | |
| 73..... | 10 | Raw-hide. | D | .. | Suture infection. | " | " | .. | .. | 2 |
| 87..... | 4 | Rubber plate. | .. | R | ..... | .. | " | .. | 60 | |
| 141..... | 4 | | D | .. | Suture infection. | " | " | 4 | 45 | |
| 136..... | 4 | " | D | .. | Gangrene | " | " | .. | 40 | |
| | | | 14 | 8 | | | | | | |

Mortality, 63 per cent.

*Experiment No. 132.*—Dog; weight, 35 lbs. Ball entered obliquely into the abdomen; five bowel perforations. Seven inches of small intestine were resected and the incised end united by circular enterorrhaphy; the continuous stitches made the operation much the same as Jobert's operation. Dog was quite ill on the second and third and again on sixth and seventh days, but recovered well.

*Experiment No. 136.*—Dog; weight, 35 lbs. Shot. Four perforations, of which two were anastomosed with segmented rubber plates, and graft applied; two were joined where the gut was severed, nearly three-fourths, by a continuous Czerny-Lembert suture with graft. Dog died 55 hours later from infection appearing at the point of enterorrhaphy and close to where the mesentery was ligated. The wounds were healing well, and the plates in excellent condition; the graft had quite firm adhesions.

The continuous suture as a sole means of performing enterorrhaphy should be unhesitatingly condemned; especially so when the Czerny suture is made continuous, and the operation completed with a continuous Lembert stitch. Such means are unsound and unwise, as they are followed by strictures and leave long threads dangling in the bowel offering excellent opportunity for fæcal fistula.

The following dogs were shot in various positions with a 32-100 ball, through the abdomen, and left to their fate, though no operation was performed; they were under daily observation:

*Experiment No. 165.*—Bitch; weight, 8 lbs. Shot transversely through the abdomen while on her hind feet. The ball passed entirely through the abdomen, and she died in 80 minutes. Autopsy revealed five holes in the bowels, and pancreas perforated. Death was due to hæmorrhage.

*Experiment No. 164.*—Bitch; weight, 60 lbs. Shot while on hind feet, the ball passing in antero-posterior direction; it entered the abdomen two inches to the left of the median line, near the navel, passing through one intestine, making two holes. She died inside of ninety minutes from hæmorrhage. The bleeding was so profuse that almost all the blood in the animal was found in the abdominal cavity, warm and not clotted.

*Experiment No. 168.*—Dog; weight, 14 lbs. Shot transversely through the abdomen while sitting on haunches. I killed him five days later, and found the *alimentary canal was not perforated.* The ball passed through the edge of the liver and omentum, and grazed the great curvature of the stomach. There existed a very local, circumscribed peritonitis; no blood-vessel of any considerable size was cut. The animal was sure to recover.

*Experiment No. 158.*—Dog; weight, 15 lbs. Shot transversely through abdomen while standing naturally; was quite ill for five days, then picked up and ate well for eight days. Five days later I killed him, to observe what damage the bullet had done.

Autopsy showed the missile had passed entirely through the abdominal cavity, but had not wounded any intestine, though it had passed through mesentery, through edge of reflex, and between two blood-vessels, but without cutting any of considerable size. The wounds were healed nicely, a slight scar appearing in spleen. This demonstrates a rare case where a ball passes transversely through a dog's belly without wounding a gut, especially when the dog stands on all his feet, and the ball enters just posterior to the navel, in close proximity to the coils of the small intestine.

*Experiment No. 157.*—Dog; weight, 15 lbs. Shot transversely through abdomen while lying on the back; died in 15 hours from hæmorrhage. Autopsy showed five perforations, three abrasions, and one hole through the spleen. Two of the abrasions were gangrenous. It was observed the intestinal perforations deviated six inches from a straight course. The wounds extended from eight inches above the anus to upper part of duodenum. Inflammation was spreading fast. The whole abdominal cavity was interspersed with blood-clots derived from superior mesenteric and a few smaller arteries.

*Experiment No. 167.*—Bitch; weight, 14 pounds. Shot transversely while standing naturally, ball passing through abdomen; she died in eighteen hours of shock and infection due to fæcal effusion. Ball passed through small and large lobe of the liver; tore

a long oblique hole through the pyloric end of the stomach. Inflammation was quite apparent six inches distant from pyloric perforation. A small perforation in duodenum. She was terribly hurt and exhibited excruciating pain for thirty minutes; then lay down, panted, and showed desperate distress for an hour more, when profound sickness was manifested until death.

*Experiment No. 169.*—Bitch; weight, 20 lbs.; shot and no operation performed. After she was chloroformed, she was shot with a 32-100 ball while lying on her side on the floor. The missile passed through the abdominal cavity, just above the umbilicus.

She died four days after the wound was received. The cause of death I considered was slow venous hæmorrhage; there was almost a pint of dark (venous) blood in the abdominal cavity. The intestines (small) presented a most remarkable condition. The bullet cut holes in the small intestines, and several in the mesentery. I might seem to exaggerate when I say that these six holes, so far as a careful autospy demonstrated, were securely hemmed in. The new lymph deposit, with the aid of the great omentum, had securely sealed up each hole. This was a most wonderful example of progressive fibro-purulent peritonitis. Layer after layer of lymph had been deposited and laid down so that the infective invasion had been effectually checked. It did appear

that the animal would have recovered if excessive hæmorrhage had not carried her off. It shows to me that hæmorrhage calls more loudly for laporotomy than gut wounds. The use of the great omentum never came to me so forcibly as in this case. It filled up the gut holes, and even acted as a gut wall where the wall of the bowel was torn away by the ball. In this case the great omentum limited the effusion of intestinal contents, and very effectually checked the infectious invasion. The peritoneal plastic exudates were enormously extensive, and where the omentum acted as a gut wall, the exudates had made it as thick as the actual gut. The whole small intestines were being cemented into a solid mass by the rapid and wide-spread peritoneal exudates. The lymph deposit was spread over large areas, but thickened in close proximity to the wounds.

*Experiment No. 170.* — Dog; weight, 25 lbs. Animal shot with a 32-100 ball while he lay on the floor; no operation performed. The ball went transversely through the abdominal cavity, close to the umbilicus, but I shot him mainly through the inferior abdominal wall so that the ball would not cut very many holes in the intestines. He quickly recovered without shock. He did not manifest much pain after a few hours, and ate and drank and played as if nothing had occurred. Eight days after the wound was made, I considered him perfectly safe so far as the gunshot wound was concerned. He was killed, and

the abdominal cavity was found perfectly healthy, except a small point on the left side of the rectus abdominalis, where a little piece of the edge of the great omentum presented an adhesion—the only remains of the bullet-hole discernible in the abdominal cavity on the left side. A slight scar showed the bullet-hole on the right side. In this case the ball had passed distinctly through the abdominal cavity of a 25-pound dog, and did not cut a gut nor penetrate a single mesentery.

*Experiment No. 171.*— Dog; weight, 15 lbs. Animal shot through the abdomen, near the umbilicus, and died ten hours after the reception of the wound, from shock or intestino-peritoneal septicæmia. No operation was performed. The autopsy demonstrated five holes in the intestines, and out of each hung long strings of mucous and food; some of these mucous strings were a foot long. The spleen was perforated. Hæmorrhage in this case was quite small. About three ounces of blood were found in the abdominal cavity. Probably if he had lived longer he would have had serious hæmorrhage. Intense congestion and inflammation existed. The great omentum did nothing for this dog, as the intestines which were cut lay at a distance posterior to the great apron. Nothing but an operation which had the object of closing these gut-holes would have saved this dog. These cases demonstrate how futile it is to attempt to diagnose a gunshot wound without laparotomy.

*Experiment No. 172.*— Dog; weight, 30 lbs. Animal shot and no operation performed. The ball was shot through the abdomen, near the middle of the belly. He suffered from some shock, but in less than two days was eating and drinking, and looked well and safe. I killed him four days after the shooting. The autopsy showed that the abdominal cavity had had some hæmorrhage in it. After careful searching, I found that the ball had entered the stomach near the cardiac end, and passed out again some 8 inches distance from the pyloric end. The holes were completely closed and securely filled by plastic exudates, and strong adhesions to the local wounds. The stomach perforations were first plugged by the mucous membrane of the stomach. The holes were much more visible on inside of the stomach than the outside. The dog appeared happy and well. The bullet just missed the gastro-epiploica dextra.

These experiments convinced me that simple gut wounds will often heal without operative interference, and also that hæmorrhage is the most formidable and dangerous form in gunshot wounds of the intestines or abdomen. However, this is not strange, the moment we pay a little attention to the anatomy of the viscera, and observe what enormous blood supply attends the abdominal organs. If a man will inject simply the superior mesenteric artery of a dog, and then dissect it out, so that the vasa in-

testina tenuis alone with all its arches, and anastomoses are seen, he will be exceedingly puzzled to know how a ball could go within the abdomen and miss such a mesh and net work of vessels, without cutting a dozen or more; man's abdomen differs but little in this respect from a dog's. The blood vessels we have found wounded in all these experiments have mainly been the cœlic axis, the superior and inferior mesenteric arteries. If the trunks of those arteries were wounded, death went generally swiftly onward and swiftly downward. I never tried tying any of the large trunks to note whether collateral circulation would supervene to prevent gangrene; that must be left for further experiments.

*Summary.*—This list comprises ten dogs shot through the abdomen in different postures, with no operation. Four died of hæmorrhage, two of shock and infection, and four recovered. Two remarkable results were obtained, in that the ball passed entirely through the abdominal cavity at about the navel without perforating a bowel. I had never before obtained a like result through a shooting of more than forty dogs; when the bullet penetrated the peritoneal cavity, the alimentary canal invariably had been perforated. In experiments, 5 per cent. showed a ball could penetrate the abdominal cavity and not cut a gut; 40 per cent. died of hæmorrhage, which is very significant; hæmorrhage calls for laparotomy, at times, louder than

bowel perforations, and it appears to the writer that the profession in general is not yet thoroughly impressed with the importance of the matter. In the list of 22 dogs which I shot and attempted to save, several would have died of hæmorrhage but for operation. It was occasionally remarked on opening the belly after a shot, that the dog would have died quickly had the hæmorrhage not been arrested. That a large ball can pass entirely through the abdominal cavity without perforating intestine in 5 per cent. of cases will arouse the attention of the profession. Dr. Senn and Dr. McGraw have put on record similar observations. Further experiments in this field will yield more desirable results, and will show the surgeon that the position of the subject when wounded, and the direction of the ball, will indicate in some measure the amount of damage done in the abdominal cavity. Balls going in an antero-posterior direction, generally do less damage than balls going in a transverse direction. In this manner the position of subject, the direction of the bullet, the size of the missile, and the location of injury, will yield valuable information for future use.

# CHAPTER XXIV.

## CONCLUDING PROPOSITIONS.

The following represent a general review of experiments.

Twenty-two dogs received 102 intestinal perforations giving an average of 4.6 for each. The highest number of perforations was 13; the lowest 0. Of the twenty-two gunshot experiments, eight ended in recovery, and fourteen died—mortality of 63 per cent. The causes of death were: Gangrene 4,—owing to blood supply being cut off in the mesentery: Shock purely, 2: Fæcal fistula 2, arising from sutures: Infection received at operation, 2: Infection starting at bullet hole, 1: Dis-invagination of a bowel end, 1.

The object of the experiments was not high rates of recovery, but an inquiry and investigation into intestinal gunshot wounds. As a result I feel convinced practice, alone, will lessen the mortality. In case of destruction of the mesentery, one only knows by some practical experiments what the limit of its vitality is.

Four dogs died of gangrene which could be lessened by better knowledge of mesenteric wounds; most beginners ligate the mesentery too freely with resulting gangrene. The mesentery was more or less wounded in 16 out of the 22 cases—I did not take special pains to collect the exact number of wounds

that each viscus received, but the liver came first, the pancreas next, then the bladder (if full), then the spleen, and finally the kidneys.

Wounds of the intestinal canal, from bullets, are absolutely uncertain in diagnosis, therefore laparotomy is recomended early in every case where the bullet enters the peritoneal cavity.

The object of laparotomy is: To discover and repair wounds of the alimentary tube and abdominal viscera: To arrest hæmorrhage—hæmorrhage from the mesenteric and other arteries in gunshot wounds of the abdomen is much more important than generally accredited; I know of one case where a physician was repeatedly requested to operate (the patient declared "I feel I am bleeding"), but lacked the courage and skill; the autopsy demonstrated an abdominal cavity almost full of blood.

The median incision is the most suitable to the majority of cases, and heals better than the lateral.

Hydrogen gas insufflation is an invaluable means of demonstrating the need of laparotomy; I do not think it is infallible, however, for *all* gun-shot wounds of the abdomen.

Early laporatomy is the only safe operation in gun-shot wounds of the intestines. Late laparatomy has shown itself unjustifiable, except for distinctly establishing fæcal fistulæ.

Where two intestinal perforations are not too far apart, anastomosis with segmented rubber or raw-hide

plates appears to be a safer operation than the Czerny-Lembert suture.

Visceral hæmorrhage outside the tube can be controlled by the Paquelin cautery, by tampon, ligature, or peritoneal graft.

Extirpation of the kidney, spleen, part of the liver, part of the pancreas, and portions of the bladder, are attended with recovery.

General agreement has long accorded to salines the best remedy in incipient peritonitis.

Exploration in peritonitis is becoming a recognized surgical procedure.

Distinct shock appears in nearly all dogs shot through the abdomen. They recover better from all other wounds.

The essential points to be observed in circular enterorrhaphy are:

It paralyzes the segment of the gut: It is followed by stricture: The lumina of the tubes may be different in size, and hence difficult to unite: It requires too much time: The pathological condition of the gut retards healing: It should not be done solely with a continuous suture: The mesentery should be carefully stitched over part of the bowel not covered by peritoneum: If too much bowel-end is inverted, it is liable to continue indefinitely to invaginate: It should be done with a continuous Czerny suture and an interrupted Lembert: Grafts should always be applied: Fæcal fistulæ are liable to occur: The sutures can be silk or linen.

Dr. C. S. Miller reports, from several experiments on circular enterorrhaphy, that less narrowing of the gut lumen occurs when the everting mucous membrane is dissected off. He thinks the healing is better from the greater amount of healing surface. Every operation was a success, though all were the second performed on each dog.

The substitutes for complete circular enterorrhaphy are: Anastomosis: The author's operation of invagination: Jobert's operation: Artificial anus.

Lateral anastomosis in the alimentary tube may be considered to give the safest operation with the least pathological disturbances of any bowel operation. It consumes the least time and disturbs the least vital tissue.

The main objects to be noticed in bowel obstruction are: General peritonitis: Adhesions (Littres' hernia): Local peritonitis: Stricture: Stricture will arise from everting too much of the divided bowel-ends in performing circular enterorraphy: A tube narrowed one-half or one-third of its original size is in danger of accidental mechanical obstruction from indigested particles, foreign bodies, and other accumulations: The disturbance in obstruction is produced by irritation of the nerves at the seat of occlusion: The danger of obstruction lies in the excessive peristalsis caused by the periphereal nerve irritation, and also the irritating, decomposing, fermenting fæces at the seat of obstruction; merely closing the gut lumen or

arresting the fæcal circulation does not cause the pathology: Animals will live weeks, at least, with complete arrest of fæcal circulation, if there be no irritation at any one point of the bowels; this test can be made by opening a dog's abdomen and completely dividing a gut, closing both ends by invagination and suture and dropping them into the cavity with closure of the abdomen. The dogs show little pathology for long periods: Non-malignant obstruction is completely relieved by anastomosing the tube above to the tube below the point of obstruction, with segmented rubber or raw-hide plates: Malignant obstruction is relieved by resection and subsequent lateral anastomosis: Substantial relief arises in obstruction from irrigation of the stomach: Early laparotomy in obstruction is generally safe: Late laparotomy in obstruction is generally fatal: In acute obstruction, the stool is almost always liquid above the seat of occlusion: In obstruction from constipation, the patient is frequently relieved in stools by a tunnel through the fæcal mass: Immovable obstruction, except through surgery, is generally made fatally worse by cathartics.

The salient features of peritoneal or omental grafting are: Grafts should always be employed in repairing intestinal wounds: The omental graft is the best: The grafts should be completely severed from the omentum: If the graft is not separated from the omentum, it may create an arch under which

intestines may become occluded: The graft can be applied first and then cut, or first cut and then applied: The graft should be sutured in position, both on the bowel and mesentery: Grafts heal best with scarification on the bowel, mesentery, and graft: Grafts rarely lose their vitality in the abdominal cavity: The graft should be larger than the wound in the bowel: In circular enterorrhaphy the graft should be large enough to reach completely around the bowel, and be sutured to the mesentery on each side: If the wound is larger than 2 x 4 inches, more than one graft should be employed: Grafts are acquired by dissecting them from the parietal peritoneum or omentum, or by tearing them from the omentum: All raw surfaces in the abdominal cavity should be covered by a graft: A graft should snuggly coapt and come in contact with every joint of the wound, and not stretch over little depressions like a drumhead: Grafts begin to aid in closing and healing the wound in an hour, generally have quite a firm exudate in ten hours, and proliferation of new tissue begins in twenty hours: When one graft is applied over any part of another, the coapting surfaces should be scarified: Visceral wounds are often well treated by an omental graft, and it aids in checking hæmorrhage: Many a time, in auptopsies, I have observed that the graft saved the animal: In suturing grafts in position, linen, silk, or catgut may be employed.

The main points to observe in wounds of the

tube are: Longitudinal wounds on the mesenteric side should not be sutured, as gangrene frequently follows: Transverse wounds on the mesenteric side, if sutured, may be followed by gangrene, or possibly by flexion causing obstruction: Wounds having any direction on the non-mesenteric side can be sutured with good effect: Trimming the edges of bowel wounds is unnecessary: Wounds involving the complete division of the tube are healed (1) by invagination and lateral anastomosis; (2) by the author's operation of invagination; (3) by Jobert's operation; (4) by circular enterorrhaphy; (5) by artificial anus: No bowel wound should be closed without first covering its surface with peritoneum where it is naturally or artificially deficient: The point of the tube where the mesentery divides to pass around the bowel requires special attention in suturing the peritoneum over it: Bowel wounds will unite by any surface if well scarified; however, the mucous membrane should be destroyed if mucous surface is applied against any other to heal; the author's new operation depends on this principle: Serosa against serosa, scarified, heals the most readily: According to Dr. Biggs, bowel wounds are now being experimentally treated outside the abdominal cavity with animal membranes until healed, or partly healed, and then dropped back into the cavity: It should be remembered in anastomosis, that wounds of the tube are smaller when healed than when made.

The features of mesenteric wounds are, gangrene and hæmorrhage. If the wound is small it can be left untouched; if large should be sutured to prevent aperture traps: The dangerous mesenteric wounds are those near the tube, as they give rise to gangrene; also those which cut a large blood-vessel at a distance from the tube, followed by hæmorrhage and gangrene; eighteen per cent. of the twenty-two dogs shot, died of gangrene.

Mesenteric wounds heal best when scarified: All sutures should be applied parallel to the blood-vessels in the mesentery: The mesentery is easily shortened by making a reef and tuck in it, and suturing it in position: The omentum should be respread over the intestines; After opening the abdomen to get at the intestines, push the omentum to the left: In working on the mesentery, one should avoid wounding a mesenteric gland.

Resection of the tube should be practiced: When the mesenteric border is much damaged: When several wounds appear close together on the tube: In malignant growths: In gangrene (if the gangrene patch be small it can be inverted into the bowel lumen and closed from the peritoneal cavity by a few Lembert sutures). Resection of more than one-third of any animal's tube is generally fatal from trauma. Resection of one-fifth or about three feet of a dog's tube generally resulted in death from marasmus. It is noticed by observers that the non-resected tube be-

comes hypertrophied and increases its functions. The mesentery should be ligated in separate parts as it might shrink and slip out of the ligature. To prevent large collections of blood (hæmatoma) in the mesentery, one should ligate the large blood-vessels separately, artery and vein. Resection should not be practiced for non-malignant obstruction, but should be replaced with anastomosis with plates. Shock is very prominent in resection.

The physiological exclusion of a long piece of the tube is compatible with normal digestion; I have excluded the tube from stomach to rectum and the dog lived fairly well for some weeks—until killed; but the general results are: Digestion is impaired in proportion to the extent of the tube excluded: Marasmus follows: Fæces do not accumulate in the excluded bowel: The excluded tube gradually atrophies, contracts and shrinks: A congestion will first be observed in the mucous membrane of the excluded tube, and then it pales with time: Physiological exclusion is accompanied by far less vital disturbances than a resection of the same extent: Peristalsis prevents accumulation of fæces in the excluded portion, in any direction: I have excluded physiologically and anatomically one-third of a dog's tube, and it lived quite well until killed. Five feet of the small bowel was crowded full of fæces and completely divided and closed at both ends by invagination and suture. It was dropped into the abdominal cavity,

and the bowel circulation, continued by uniting the other two divided ends by lateral anastomosis. The dog was finally killed and the fæces in the excluded bowel had become liquified and green microbe; the bowel was slightly fuller than when operated on. Secretion had slightly been in excess of absorption, but I think that was merely temporary from reaction.

The characteristics of bowel invagination are: It arises without known cause: It is mainly a disease of childhood: It is closely connected with the development and diseases of the spinal centres: Disinvagination occurs spontaneously, in a vast majority of cases: Accumulation of fæcal contents above the seat of invagination, is the most disastrous element; it prevents dis-invagination, and causes gangrene and perforation of the tube: The distinctive element is the peristalsis instigated by irritation of the peripheral nerves at the seat, and abeted by acrid decomposing fæces: The dangerous element is the perforation of the tube, and fatal peritonitis: Gangrene occurs first at the neck and apex of the intussusceptum: Gangrene is caused by the obstruction of the venous blood, and it collects at the point of least resistance, which is in the convex border of the intussusceptum: The large sausage-like tumor and swollen knob on the intussusceptum has much to do with preventing disinvagination: Irreducible invagination can be left in position, and the bowel above be anas-

tomosed to the bowel below with plates, or it can be resected and the tube anastomosed: Injections of fluid or gas can be used if the invagination is below the ileo-cœcal valve, but only gas should be used if it be above that valve: Invaginated ends of bowel must not be inverted too much, or invagination will continue indefinitely; the way to avoid it is to only invert about one-half inch of the bowel, and that gives no purchase to the bowel muscle to act further: The relief of fæcal accumulation by directing it through a new channel (an anastomosed channel), and the relief of peristalsis on the invagination, generally prevents further pathological change in the invaginated parts, and they recover and atrophy like an excluded bowel: Early anastomotic operation will save irreparable gangrene: Short attacks of colic are likely conditions of invaginations which disinvaginate themselves: Blood appears in the stool in 80 per cent. of cases of invagination: About one-third of invagination tumors reach the rectum: Invagination will travel several feet in twenty-four hours.

The ileo-cœcal valve is permeable to air or gas, but to attempt to force fluids through it from the rectum, experiments demonstrate is unsafe and unjustifiable. Water injected through the valve from the rectum passes the valve only by over-distension of the cœcum, and a mechanical separation of the edges of the valve. Fluids or gas cannot be forced beyond the stomach by way of the mouth with safety. I have ruptured the stomach in trying it.

In the experiments, dozens of flexions occurred, at almost any kind of angle, but I never saw a flexion cause obstruction.

No flexion, volvulus, kink, or adhesion, will cause obstruction to fæcal circulation unless the peristalsis of the bowel is destroyed.

Jobert's operation with two fine, untanned catgut invagination sutures, is safer than circular enterorrhaphy; it should be strengthened by two to four Lembert sutures. Jobert's operation is not safe, without a rubber ring, or better, a rubber tube, to keep open the bowel end, or without a graft. The operation is not safe without invagination sutures, as the invaginated distal bowel would invaginate indefinitely; the invagination sutures secure in fixed position the distal invaginated bowel preventing disinvagination or further invagination. If the invagination sutures produce fistulæ (which they did in some experiments) the well applied omental graft will limit the inflammation.

All anastomoses should be made by lateral coaptation of the convex surface of the alimentary tube, by the aid of plates (or rings) and well applied grafts.

If the gall duct is divided, it is best treated by directing its proximal end into the bowel and fixing it there by sutures. A little rubber tube should be temporarily stitched in to keep it open a few days. If a ureter is divided, both ends should be directed

into the bowel and fixed by sutures. If there be but the distal end, it should be directed into the rectum, as the experiments demonstrated that urine would regurgitate from the bladder through the ureter into the abdominal cavity (proving fatal in one case).

Inoperable neoplasms, irreducible invaginations, and strictures of the tube, are best treated by anastomosing the parts above and below with plates. It relieves suffering to the inevitable end of a fatal malady, or restores health in benign diseases.

In cases where gangrene of the intussusceptum is present, resection may be avoided by invaginating the gut further until healthy bowel meets, and fix it position by suture and apply a graft, then anastomose with plates at a healthy distance from the seat of invagination.

In anastomosing, extensive physiological exclusions must be avoided as marasmus will follow.

Scarification of serous surfaces or dissection of the mucous membrane at the joint of approximation induces rapid healing.

In gastro-enterostomy the artificial or bimucous fistula generally contracted $\frac{1}{8}$ to $\frac{3}{8}$ smaller than its original size. In the intestinal tube the contraction was not so much. The ultimate artificial fistula should be of the same size as the part of the tube in which it exists.

Plates are superior to rings in anastomosis from coaptation of large surfaces, and mechanical and

physiological rest. The ideal plate would be one with no sutures, and which would be held together by a contrivance that would break down at definite periods.

Definite periods for the appearance of peritoneal exudates can not be relied on. It may occur in a few hours and again be delayed strangely long—a day.

Gastrostomy or enterostomy is best done by rubber ring or rubber plate armed with four to eight sutures.

Pylorectomy was improved by Loreta's operation of dilatation, by the Heineke-Miculicz pyloroplasty procedure, but gastro-enterostomy with segmented rubber or rawhide plates is a safe and reliable operation.

Artificial or preternatural anus is best made in the left groin. The parietal peritoneum should be sutured to the skin in the incision. The bowel loop is then drawn out and fixed by sutures in this incision, and opened at pleasure. Artificial anus is justifiable in: Inoperable neoplasm of sigmoid flexure and rectum: Congenital atresia of the bowel beyond reach: In irreducible colon invagination, where resection is impossible: In patients unable to bear severer operations.

Clinical experience, statistics, and my experiments, clearly show that there is a very great difference between a shot wound, and a stab or penetrating wound, of the abdomen. Shot wounds are far the

most dangerous and fatal, and call for prompt surgical treatment more frequently. Hæmorrhage, extravasation and shock are generally more prominent in shot wounds of the abdomen.

Experiments have often demonstrated that a fæcal fistula would be found in the gut wall at the seat of operation, and yet the animal's life be entirely safe from the protection afforded by the graft. The graft would thicken at the point of fæcal effusion until the point was stronger than previous to the operation.

The diagnosis and treatment of gunshot wounds of the abdomen, involving alimentary perforations and visceral infusions, can only be properly done by training acquired by experiments on the lower animals. Operations on the cadaver, or observations of operations by others, will never give the skill and dexterity that is acquired by experiments on living animals.

Proper use of the hydrogen test, and the limits of visceral vitality, are alone the legitimate results of work on the lower animals. I urge, without expectation of contradiction, the absolute necessity of special training, acquired skill and dexterity, in any one who attempts to perform in the field of gunshot wounds of the abdomen.

My experiments demonstrated that when a dog stood on his hind feet and was shot antero-posteriorly in the abdomen, there were chances that, though the

ball entered the abdominal cavity, the alimentary canal would escape being perforated. But in these very same cases death would occur from *hæmorrhage.*

In the experiments of some 40 cases in transverse shooting, with the dog on his back, side, standing on his four feet, or on his hind feet, every time the ball entered the peritoneal cavity it wounded the gastro-intestinal canal, and generally severed more blood-vessels than the antero-posterior shooting. If the ball entered transversely below or about the umbilicus, multiple bowel perforations were found on section.

The general and local symptoms in gunshot wounds of the abdomen, with the exception of fæcal extravasation, are of no positive value in diagnosing visceral lesions requiring surgical aid.

In using the hydrogen gas test to diagnose intestinal perforation in gunshot wounds, experiments showed positively that the patient should be anæsthetized.

Hæmorrhage alone is sufficient cause for laparotomy in gunshot wounds of the abdomen.

In the use of air or hydrogen gas for rectal insufflation, the lowest intestinal perforation will be first indicated; then, to save waste of gas or refilling of the tube from rectum to the perforation, the bowel should be inflated from the perforation first found, to avoid manipulation of the intestines,

Direct inflation of the stomach is easier than to inflate it from the rectum.

Dr. N. Senn suggests that to test whether a wound of the abdominal wall has penetrated the peritoneal cavity, the wound should be plugged at one end and then hydrogen gas forced into the other end. If the gas meets resistance, it shows no peritoneal penetration; but if not, the gas will distend the peritoneal cavity.

The medico-legal aspects of gunshot wounds of the abdomen are assuming vast proportions. They rest on the course followed by the surgeon, and will be based on three points:

Should laparotomy be done? Should laparotomy not be done? Should the hydrogen gas be used?

If a patient die of hæmorrhage with no laparotomy, the surgeon is blamed. If the patient die of peritonitis from fæcal effusion, with no hydrogen gas test and no laparotomy, the surgeon is to blame. The sentence of the criminal, in most cases to-day, will depend on the course of the physician toward the patient. If a surgeon performs a laparotomy and finds no bowel perforation, and the patient dies from shock or peritonitis, the surgeon is blamed.

The surgeon may, by laparotomy, save life by arresting hæmorrhage by closing fæcal fistulæ or repairing any mortal wound, and thus change a case from a murder to a mere case of assault and battery, *e. g.*, a bullet might simply cut the ureter and the surgeon save life by extirpating the kidney, which would change a case of murder into another kind of case

My experiments demonstrate the exposure of the viscera of dogs over forty minutes endangers life from shock. Several dogs died from simple exposure and manipulation of the intestines. Hence, the legal aspect of the question will raise the point of the amount of time consumed in the operation. The trouble in such trials is that a physician is not tried by his peers but by a lay jury, who are always unfitted to judge whether the patient died from the injury inflicted by the wound or causes due to the physician's neglect or ignorance. I observed no dog die from visceral exposure of less than forty minutes. The shock was often in proportion to low temperature.

* * * *

I wish here to express my thanks to those who have worked with me through the three years of experiments. The labor of continuous experiments is considerable, and I owe many thanks to those who have shared in the work. Part was done at Grand Rapids, where I was assisted by Dr. D. D. Bishop (and who likewise performed some experiments successfully). I also owe many thanks to Mr. B. M. Vaughan and Mr. Copeland, for kindly aid. Dr. Boorman assisted at some of the work.

The last year's work has been done at Toledo, Ohio, and I have especially to thank Dr. C. S. Miller for his large share therein; Dr. Miller labored the entire year, and personally performed a number of the operations; he also made many suggestions which

proved most valuable, and now announces a new operation on the intestines which he is experimenting with preparatory to publication. Dr. Zetlitz proved a good man to give chloroform, and performed some excellent experiments; also Dr. W. V. Anderson lent kindly aid and performed not a few experiments, as did Dr. W. J. Gillette; many of the recorded experiments were by the latter. Thanks are also due to Drs. Betts, French, and Geierman, for assistance.

# APPENDIX.

Another "aid" in intestinal anastomosis has been furnished the profession, termed the "*Chromocized Gelatin Plate.*"

The name of Dr. Shively is connected with this plate October 23, 1889. Dr. Briddon mentioned the idea at a discussion in the New York Surgical Society, which was reported by the New York Medical Journal of that date. Dr. Briddon said Dr. Shively's chromocized gelatin plate could be moulded into any shape, and could thus be placed in accurate position. I have seen no further publication of the matter connected with Dr. Shively's name.

It appears the name of Dr. Siminson, of Pittsville, Wisconsin, is also connected with the introduction of the chromocized gelatin plate. Dr. Siminson reported some experiments relative to the use and preparation of these plates at a medical meeting in Wisconsin. In a personal communication to me, which I shall assume the liberty to quote, Dr. Siminson says:

My plates (the chromocized gelatin plates) are composed of gelatin and bichromate of potash; the latter substance making it very difficult to be absorbed. They are very easily made, and are antiseptic. The *modus operandi* is as follows: Gelatin is dissolved in water and then a solution of bichromate of potash added, so that each plate contains 50 per cent. of bichromate of potash, which makes gelatin insoluble

in water, and at the same time antiseptic. I pour the mass on plates, and shape it in any desired form. The gastric and intestinal juice will slowly absorb such plates. I wish you would make a trial with them, as I am convinced they will be found satisfactory.

I have had no experience with the plates of Dr. Shively and Dr. Siminson. It appears to me the septic or antiseptic plates will make no material difference. The danger from plates lies in fæcal fistula, for the alimentary canal will tolerate and resist septic matter in its lumen. It is well-known it will tolerate even the venom of the rattlesnake with no damage, but should such venom get into the blood or peritoneal cavity, death would follow. An advantage of the new "aid" is that it is a plate and not a ring. Future trials must decide the utility of the chromocized gelatin plates, while the profession should thank Dr. Shively and Dr. Siminson for their ingenious device to improve the *technique* of intestinal surgery.

Dr. Matas, of New Orleans, has added to intestinal surgery the *solid catgut ring*. To use this aid alone, is no particular improvement over Dr. Brokaw's segmented rings which were held together by catgut strands. It is inferior to the raw-hide plate as it coapts a more limited serous surface. It is about the same in usefulness as the raw-hide ring which I used many times to hold the segmented rubber plates together, and as Dr. Matas suggested, could be used instead of the rawhide, sheep skin, or catgut.

The solid *catgut rod* which Dr. Matas gives the profession is the same as the ring only it is in a straight line. It is used to coapt linear intestinal wounds, or for linear enterorrhaphy. The rods are introduced into the intestinal wound, armed with a desired number of sutures, some two to three to the inch is a fair number. A rod is placed on each side of the bowel wound and the needles are passed through the entire gut wall. A graft should be added. The rods will soon dissolve away and the sutures will drop into the gut lumen. Much care must be exercised in the use of the solid catgut rod as fæcal fistula arises if the operation is not properly performed. These rods can be bent in the form of rings and pointed at their extremities by a thin rubber tube, and thus used to perform circular enterorrhaphy. A peritoneal or omental graft will often prove the salvation of an animal's life when sutures penetrate the entire bowel wall, as all such make it difficult to avoid fæcal fistula.

It will be noticed that the "aids" in intestinal surgery are really all based on the suggestion of Dr. Connell, that discs be used instead of suturing by the old method.

The order of dates of the various "aids" in intestinal work is shown by the following paragraphs:

1887. Dr. N. Senn's decalcified perforated bone plates appeared.

1888. Dr. Abbes' catgut rings.

* * * * *

1889. Author's cartilage plates.

In 1889, Dr. Stamm *suggested* the use of the cartilage plates independently, and he has lately had splendid success in using them on a boy 12 years old.

1889. Dr. Brokaw's segmented rubber rings.

1889. Author's raw-hide plates.

1889. Dr. Davis' catgut mats and solid catgut plate.

1889. Dr. Siminson's and Dr. Shively's chromocized gelatin plates.

1890. Author's segmented rubber plates.

1890. Dr. Matas' solid catgut ring and solid catgut rod. After sending my manuscript to press, I met Dr. R. Abbe, of New York, who informed me that Dr. Penrose had invented a rubber disc for intestinal anastomosis. I was unaware of Dr. Penrose's plate until informed by Dr. Abbe.

The "aids" in intestinal surgery, consist at present of eleven devices, all proposed inside of three years as the result of animal experimentation; and in every instance the product of American genius.

* * * * * * * * * *

Cuts No. 1, 2, 3, up to 14, are taken from an article in the *New Orleans Medical and Surgical Journal*, for August, 1890, written by Dr. R. Matas, of New Orleans. I wish to thank Dr. Matas for the courteous permission to use them.

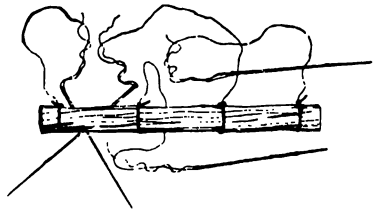


FIG. 1.—Matas' solid Cat-gut Rod armed with Transfixion Needle.—To be used as an intra-intestinal quill suture.

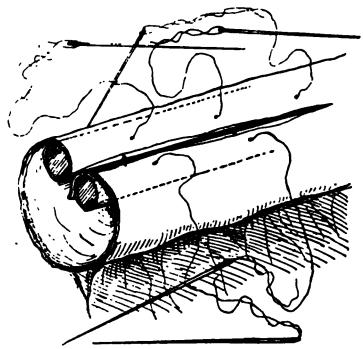


FIG. 2.—Vertical Section of Intestine, showing Cat-gut Rods in Position; Tranfixion Sutures through the Intestinal Wall. (Brokaw's Modified Suture for Linear Enterorrhaphy).

FIG. 3.—Davis' Cat-gut Mat.

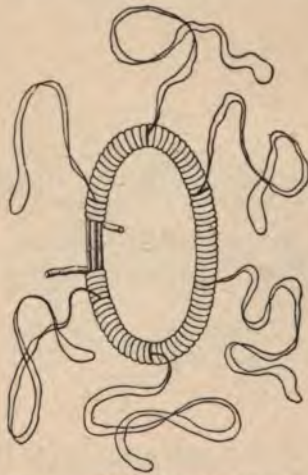


FIG. 4.—Abbe's Cat-gut Ring.

FIG. 5.—Davis' Solid Catgut Plate.

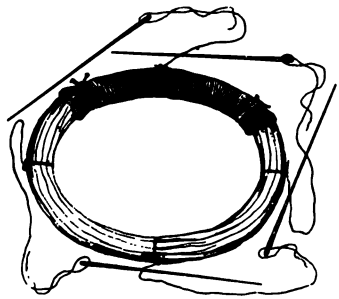


FIG. 6.—Matas' Solid Catgut Ring,—made of boiled drum-snare.

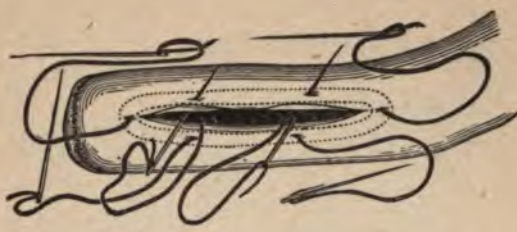
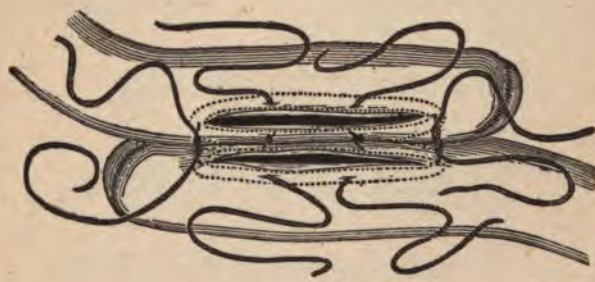


FIG. 7.—Fixing Ring in Divided Intestine. The Bowel has previously been inverted at cut end, and formed into a *cul de sac*.



TIG. 8.—The Bowels Approximated, and the Anastomotic Openings in Confrontation.

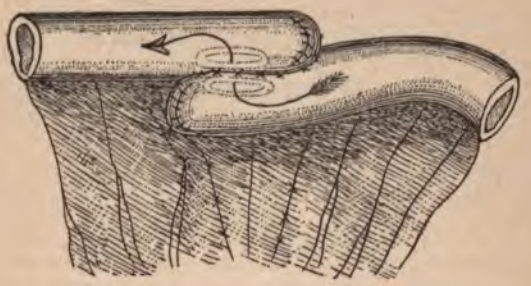


FIG. 9. Diagramatic Representation of Intestinal Circulation after Completion of Anastomosis and Enterorrhaphy.

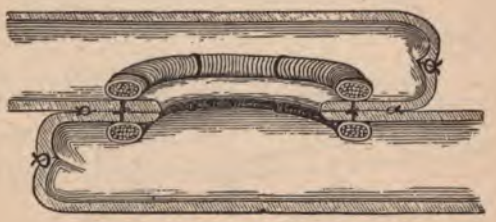


FIG. 10. Vertical Section representing Anastomatic Connections and Intestinal Interior.

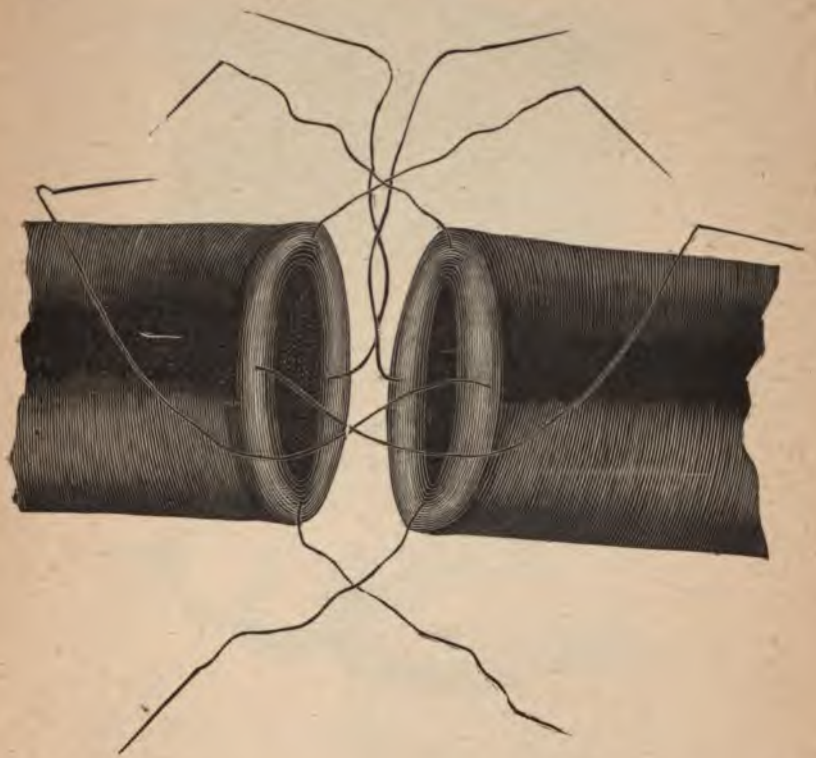


FIG. 11. Circular Enterorrhaphy with the aid of Cat-gut Rings.—The rings in situ, and the intestines in confrontation (Matas' Method).

FIG. 12.—Complete Approximation, with the Continued Lembert suture after Adjustment of Rings. Circular resection of bowel by direct lumen to lumen.—Aided enterorrhaphy (Matas' Method).

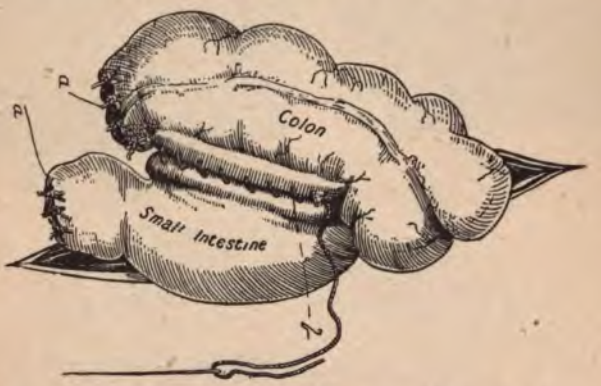



FIG. 13.—Ileo-Colostomy without Resection of Cœcum, showing Plates in position, one in the Ileum, the other in the Colon. (*a*) Lateral or transfixion suture passed through the margin of the wound. (*aa*) End ligature hanging out of the wound. (*b*) Posterior row of superficial or Lembert sutures.

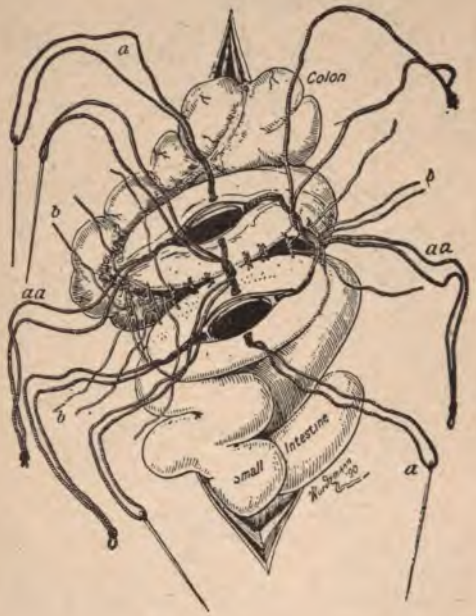



FIG. 14.—Ileo-Colostomy as seen after Resection of the Cœcum. (*a*) Closed ends of colon and ileum directed downward. (*b*) Serous surfaces over anterior margin of plates united by a number of stitches of the continued suture.

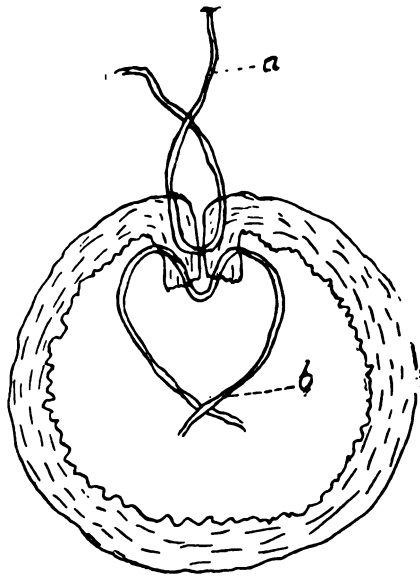



FIG. 15.—A Diagramatic Section of Gut to Demonstrate the methods of using the Czerny-Lembert Suture. (*a*) Shows the Lembert suture which penetrates the serous and muscular coats of the gut-wall, but does not perforate the mucous membrane. (*b*) Shows the Czerny suture which penetrates the mucous membrane and muscular coat of the gut, but does not perforate the serous membrane or peritoneum. Czerny's stitch can be *interrupted* or *continuous*, as also can Lembert's stitch.

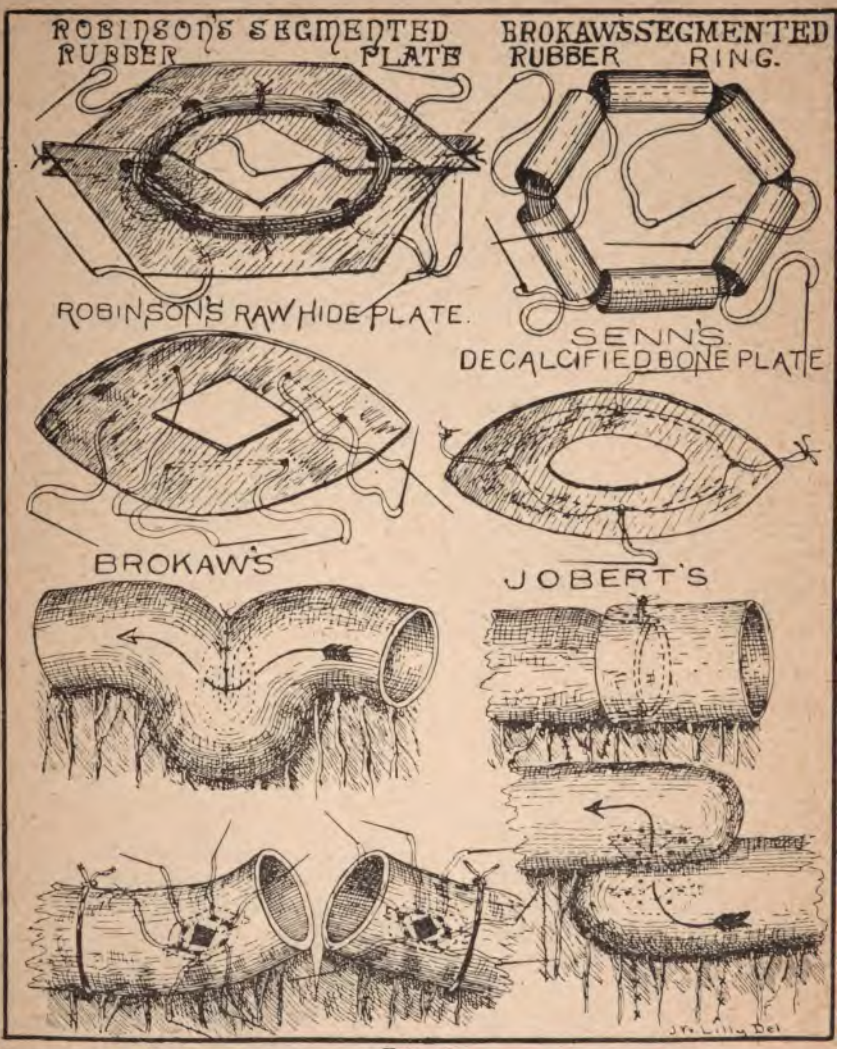

ROBINSON'S SEGMENTED RUBBER PLATE
BROKAW'S SEGMENTED RUBBER RING.
ROBINSON'S RAW HIDE PLATE.
SENN'S DECALCIFIED BONE PLATE
BROKAW'S
JOBERT'S
J.H. Lilly Del

FIG. 16.

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